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JPRS L/8925

14 February 1980

USSR Report

RESOURCES

(FOUO 4/80)

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ELECTRIC POWER AND POWER EQUIPMENT

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PLANNING AND CONSTRUCTION OF MINSK TETS-4 DESCRIBED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 10, Oct 79 pp 2-20

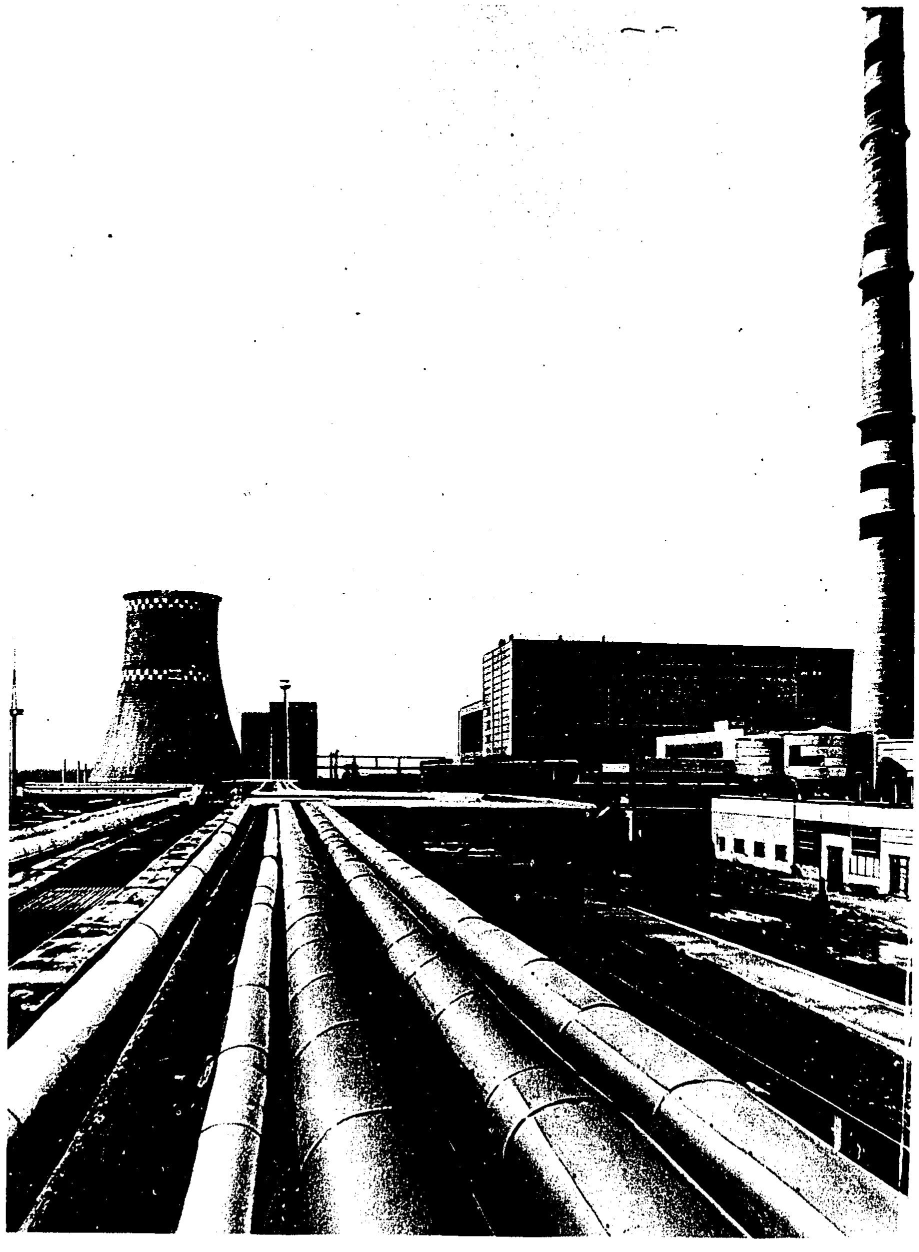
[Article from materials prepared with the participation of L.A. Kitayeva, architect, L.K. Nesterovich, candidate of technical sciences, and V.N. Bobrov, A.S. Verzhinskiy, S.A. Gershenovich, A.Sh. Katsnel'son, P.N. Knot'ko, A.G. Lozovoy, V.N. Krylov, G.L. Oksengendler, B.M. Protusevich, I.I. Rovek, S.R. Svirnovskiy, N.G. Sprishen, F.E. Chernyak, I.M. Shavel'zon, M.D. Shif and I.P. Shporta, engineers: "Planning and Construction of Minsk TETs-4"]

[Text] Architectural Arrangement of the Complex of Structures

The complex of structures that make up Minsk TETs-4 is located in the southwestern part of Minsk, not far from the belt highway and a prospective apartment region. In selecting the layout for the basic objects in the electric power station (main building, chimney stack and cooling towers), the factors taken into consideration were their effect on the surrounding landscape, the good view from the belt highway and, from the viewpoint of the city's residential area, the fact that they dominate a very large area. It was decided to situate the power station with its permanent face and the front of the machine room toward the belt highway and the prospective apartment region, with the main access to the station being on the side of the permanent face (Figure 1).

General Plan of Minsk TETs-4's Complex of Structures. The auxiliary production services have all been grouped together in a consolidated auxiliary building (OVK). This enabled the general plan of the complex of power station structures to be more compact and efficient. The complex contains only two production buildings -- the main building and the OVK. All of the technological structures that are not suitable for grouping (the hydraulic engineering unit, the water-level maintenance unit, the network pumphouse with the deaerators) have been placed at the appropriate engineering locations and as close to the main building as possible (in accordance with the standard requirements).

Such grouping made it possible to reduce the area of the territory covered by the industrial site, the number and length of the road and connecting



Inside Front Cover: Minsk TETs-4 Under Construction.

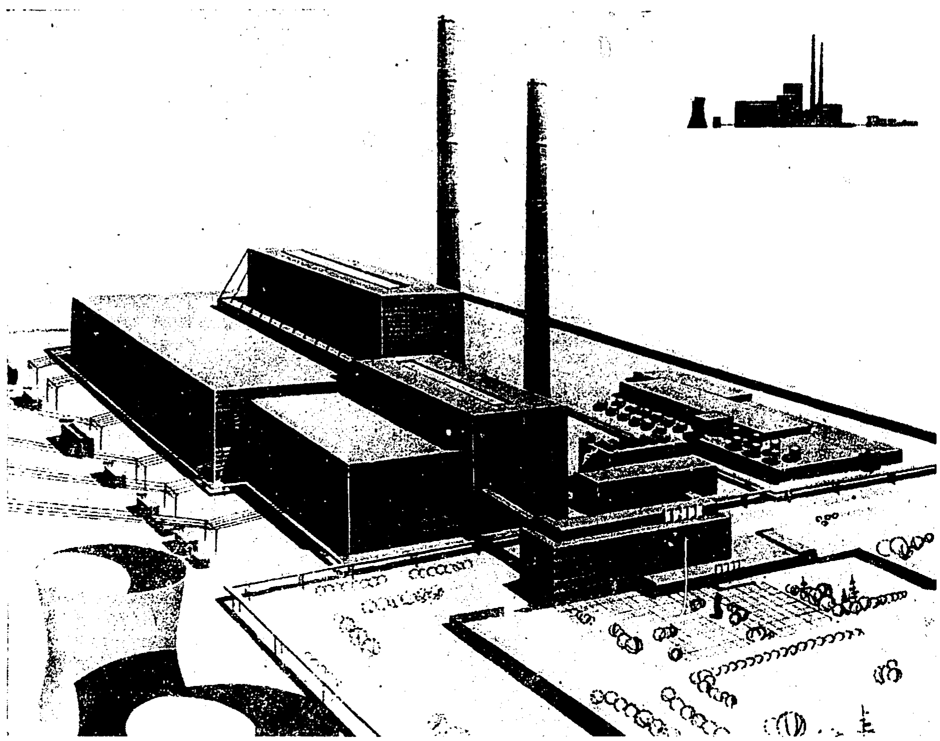


Figure 1. General view of the TETs site.

engineering scaffold bridges (which saves metal), general site communication lines and so on.

However, because of the territorial remoteness of the auxiliary production facilities (the chemical water preparation unit, in particular), a significant number of connecting pipelines involved in the basic production process still had to be retained. In the future, every effort should be made to place all the auxiliary services as close as possible to the basic production facility. The main building of Minsk TETs-4 was constructed in accordance with a TETs-ZIGM series plan developed by VNIPlenergoprom.

The plans specified the construction of the main building with standard construction engineering sections. These, in turn, consist of consolidated, three-dimensional construction engineering elements with an increased degree of plant finishing. The sections also include consolidated elements for the enclosing structures: surface-finished cellular concrete wall panels measuring 12 x 1.8 m, vertical panels of shaped glass in metal frames that measures 10.8 x 3 m, full roof panels measuring 12 x 3 m and others.

The main building's faces are in the form of traditional stained-glass panels with metal casements; the vertical panels are made from shaped glass. However, experience in operating power stations has shown that extremely large areas of stained-glass walls result in unjustified and excessive heat losses from the building. In light of this, the question of the scale of utilization of shaped glass in the main buildings of electric power stations must be reviewed.

The Consolidated Auxiliary Building. This building was constructed according to a plan developed by VNIPIenergoprom's Belorussian Department. In the OVK we have grouped all of the auxiliary production services that were previously located in separate buildings and combined into a unified technological complex by a complicated system of overhead and underground communication links.

The OVK (Figure 2) contains: a shop for the chemical preparation of water, with an open-air tank system; a chemical reagent storehouse; centralized repair shops; a materials storehouse; a compressor house; an electrolysis room; accommodations for a unit for cleaning oily water; spaces for filter presses; a solvent unit; a heat insulation material shop and storehouse; an anticorrosion coating shop; facilities for charging the storage batteries of the electric trucks; a laundry; laboratories; personal areas for the personnel of all the services located in the OVK; service and auxiliary rooms.

All of the services and shops are located with due consideration for the specific nature of the production processes, as well as sanitary and fire- and explosion-prevention requirements[1].

The layout of the areas in the building was based on the following principles. Services occupying areas that will not be enlarged with the development of the power station's capacity, as well as those that need certain outside wall areas or foot and vehicular access to the outside, are located at the building's permanent face, as dictated by the conditions of explosion prevention.

Services with areas that can change depending on a change in the station's capacity or for other technological reasons (the filtering room, the outside tank system of the chemical water cleaning department, the lime and reagent facilities) are located in the building with due consideration for the possibility of expanding them without reorganizing the permanent part of the OVK.

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[1]Korytnikov, V.P., Markovskiy, I.I., and Kitayeva, L.A., "Grouping the Auxiliary Buildings and Structures in Plans for Series-Produced TETs's," ENERGETICHESKOYE STROITEL'STVO (Power Construction), No 8, 1973, pp 7-11.

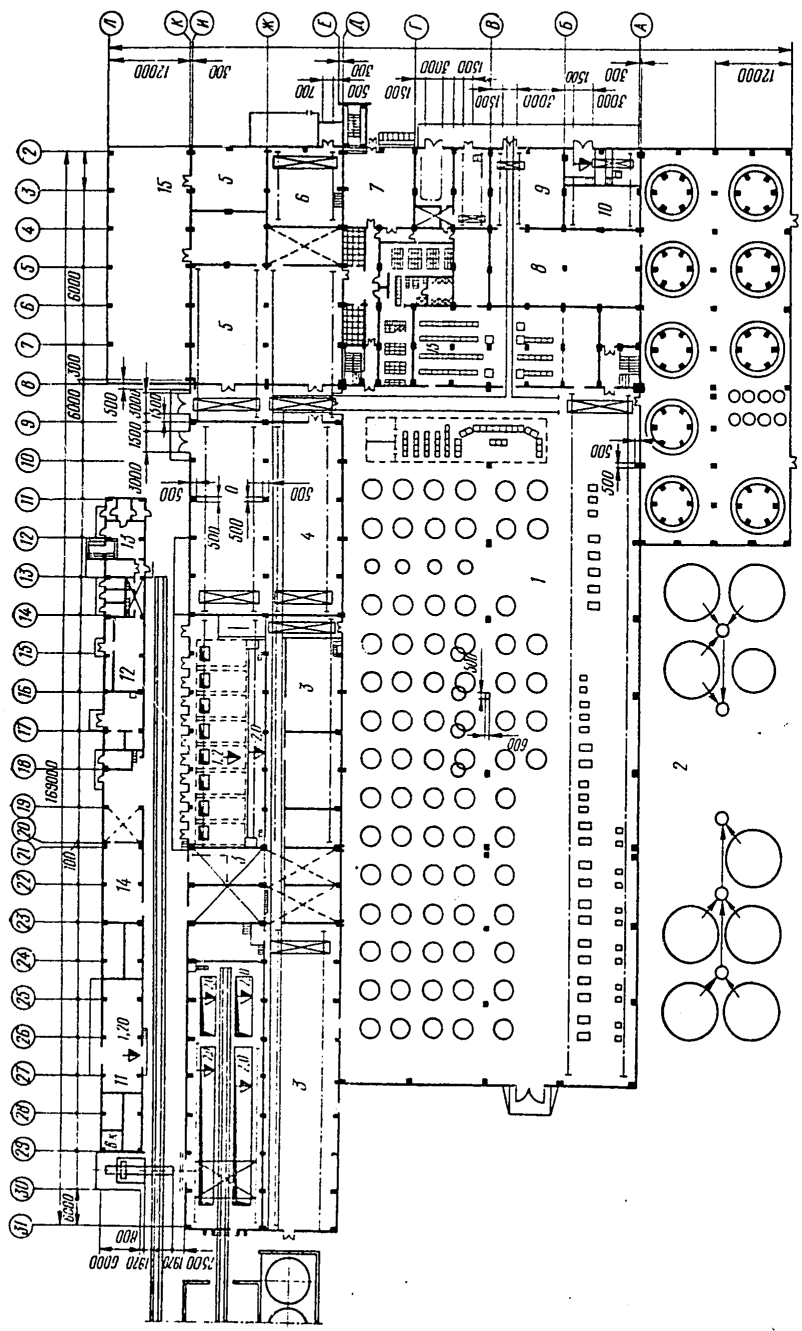


Figure 2. Plan of consolidated auxiliary building: 1. chemical water preparation shop; 2. outside tank system; 3. chemical reagent storehouse; 4. materials storehouse; 5. central repair shops; 6. compressor house; 7. lobby of main entrance into building; 8. flotation and collection tanks; 9. electrolysis room; 10. filter press room; 11. solvent unit; 12. electric truck storage battery charging area; 13. anticorrosion coating shop; 14. heat insulation material shop and storehouse; 15. shed.

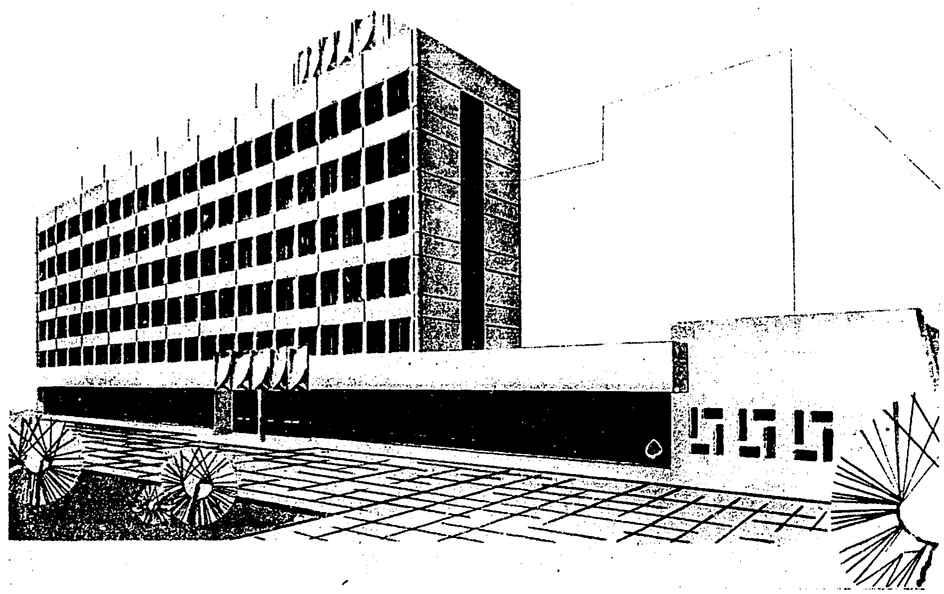


Figure 3. General view of engineering and personnel services building.

The production services that utilize processes requiring the powdering of materials (the lime and reagent systems, the solvent unit, the heat insulation materials shop and storehouse) have been grouped in the peripheral part of the building, which eliminates pollution of the production area.

Railroad access to the OVK is on the side of the temporary face (the side of the construction base). All of the building's load-bearing and enclosing structures were planned with the use of prefabricated, standardized construction elements in mind. The column grid measures 12 x 6 m. A column grid measuring 24 x 12 m was specified in the filtering room, so that the equipment could be arranged more rationally. The height of the building to the bottom of the ceiling beams is 7.2 and 6 m.

In addition to side illumination, overhead illumination through transparent roof panels has been provided for in the building.

The Engineering and Personnel Services Building (Figure 3). All of the administrative, shop, engineering, personnel and auxiliary services of the electric power station are combined in this building.

The building's main facade is turned toward the basic access route to the power station and faces the belt highway. The building consists of a basic six-story structure and an "embedded" single-story structure that contains the dining room.

The plan used for this building, which was developed by VNIPIenergoprom's Kiev Department, specifies:
the wall panels are faced with light gray tile of the "iris" type, as is the case for all the buildings at the power station; in the light openings there are shaped reinforced concrete elements between the windows that protrude from the plane of the panels and create light and shade of the necessary depth;
belt-type aluminum window casements (inconvenient to use and expensive) have been replaced with wooden ones;
the main entrance into the building, which also serves as the main entrance to the power station, has been emphasized with decorative reinforced concrete elements placed above the first story and on the buildings' parapets.

The volume of the one-story part of the building has been changed.

Thus, the grouping of detached auxiliary buildings and structures into a single unit made it possible to improve the architectural planning and volumetric-spatial resolution of the power station, order the progress of the construction on the site and utilize large volumes on the basis of standardized, consolidated construction elements.

The experience gained in planning and operating Minsk TETs-4 showed us that in the future the feasibility of combining all the auxiliary production services in a single technological building should be taken into consideration.

Technical Solutions in the Plan

Minsk TETs-4 is the leading series-produced gas-and-oil TETs with increased plant finishing (TETs-ZIGM). The basis of the Minsk TETs-4 plan was the solutions adopted in the "Basic Propositions on the Designing of a Series Gas-and-Oil TETs With Increased Plant Finishing," which were developed by VNIPIenergoprom with the participation of the Energomontazhproyekt institute and the Leningrad branch of Orgenergostroy [All-Union Institute for the Planning of Electric Power Projects].

During the planning process, other new technical decisions were adopted that make it possible to achieve a substantial improvement in the technical and economic indicators of TETs construction by changing the planning and construction technology and increasing the degree of industrialization of the construction and assembly work and the order of the production and delivery of equipment and structural parts.

In accordance with these decisions, the following elements were specified in the engineering plan:

construction of the TETs's main building from standard construction engineering sections;
delivery to the TETs construction site of production equipment and structural parts with an increased degree of plant finishing and consolidation of the elements at a regional production-assembly base set up at Minsk TETs-4;
a change from the digging of a deep basement for the main building and the installation of piling foundations under the building and the equipment.

Minsk TETs-4 is intended to take care of the basic part of the thermal loads in the western section of Minsk. (The peak part of the thermal loads are covered by the existing regional hot-water boiler units.)

The calculated heat output from the TETs is 4,338 GJ/hr of hot water, including 1,410 GJ/hr of hot water supplied for the open-air system; the heat output of the peak boilers is 3,985 GJ/hr.

In order to cope with the calculated heating-system load at the TETs, the plan specifies the following basic equipment:
one turbo-unit with a PT-60-130/13 turbine, two turbo-units with T-110/120-130 turbines, three BKZ-420-140 NGM drum-type gas-and-oil power boilers, two turbo-units with T-250/300-240 turbines, and two P-950/255 GM straight-through gas-and-oil power boilers.

The fuels for the TETs are heating oil and surplus natural gas. The annual consumption of conventional fuel is 2 million t.

Minsk TETs-4 is located close to existing railroads and highways.

In view of the fact that basic equipment that is different in unit capacity and initial steam parameters is being installed at this TETs, the main building was designed in two parts that differ from each other in size and composition: nonblock equipment designed for a pressure of 14 MPa is being installed in the first part, and block equipment operating at 24 MPs is being placed in the second.

The part of the main building that is intended for the installation of the nonblock equipment (its plan is from the TETs-ZIGM series) is being built in five construction engineering sections: the permanent face, the PT-60-130/13 turbine, the T-110/120-130 turbine (two sections) and the temporary face. The width of all the sections is 24 m, except for the temporary face section, which is 12 m wide.

The part of the main building that is intended for installation of the block equipment consists of two identically arranged units that can also be built from elements with maximum plant preparation. The width of a turbine cubice is 48 m. The adopted width for the turbine cubicles has been agreed upon with the plant manufacturing the turbines and is being realized by removing the network and circulation pumps from the main building.

Table 1.

Показатели, м (1)	Главный корпус (2)	
	неблочная часть (3)	блочная часть (4)
Пролеты: (5)		
машинного отделения (6) . . .	39	54
(7) котельного отделения . . .	36	39
деаэраторной этажерки (8) . .	10,5 (встроенная) (9)	12
Шаг основных колонн (10)	12	12

Key:
1. Indicators, m
2. Main building
3. Nonblock part
4. Block part
5. Spans:
6. Machine room
7. Boiler room
8. Deaerator stack
9. Built in
10. Spacing of basic columns

The construction of an oil management system for the reception, storage and treatment of the fuel oil has been specified. It consists of a two-way receiving and transfer unit, an oil-pump building, an outside storage area for the oil that has a capacity of 80,000 m^3 (four ground-level metal tanks that each hold 20,000 m^3), and a liquid additive installation.

The main building's basic dimensions are given in Table 1.

Minsk TETs-4's water purification system consists of the following elements:
a desalinization unit that operates with a method for complete desalinization with preliminary purification utilizing the principle of chains, with a productivity level of 280 m^3/hr;
a condensate cleaning unit with a capacity of 60 m^3/hr for oily condensate and 135 m^3/hr for iron-contaminated condensate returned from the oil management system;
a unit for producing potable water to maintain the level in the heating networks (allowing for outside water use) that can produce 6,000 m^3/hr (12 units that each produce 500 m^3/hr).

The deaerator thermal network level maintenance system, with five vacuum deaerators with capacities of 1,200 t/hr, is being constructed in the same block as the water purification system. For the removal of stack gas, the plan specifies the construction of two reinforced concrete smokestacks that are 180 m tall and will service the boilers in both the block and nonblock parts of the main building.

All of the TETs's turbogenerators are connected into blocks by double-winding transformers. The first four are connected to 110-kV ORU [outdoor distribution system] buses, while the fifth is connected to 330-kV RU [distribution system] buses. In order to supply nearby consumers, a 10-kV ORU with a separate system of buses is connected to power units Nos 2 and 3 by soldering. For the 110-kV ORU we have planned a double system of collecting bars with a bypass, with the system being divided into four sections by cutouts. The 330-kV ORU is set up as a quadrilateral; if the TETs is further expanded, it will be changed to a hexagonal arrangement. An autotransformer with a transitional capacity of 220 MV·A is being installed for coupling and the coverage of regime overcurrents.

Minsk TETs-4's engineering water supply system is a circulating one that consists of:

a supplementary water pumping station on the Svisloch' River that has a capacity of 2.27 m^3/s (including 0.9 m^3/s for the TETs) and is being built in conjunction with the Minsk Gorispolkom;
two water conduits that are each 1,000 mm in diameter and that have a total length of 10.5 km;
a central pumping station for circulating water that has a capacity of 22 m^3/s;
three reinforced concrete cooling towers, each of which has a spraying area of 3,200 m^2;
two pressurized steel water lines, each of which is 2,400 mm in diameter;
special conduits for supplying cooled water from the towers to the central pumping station.

The TETs has separate water lines for the maintenance and drinking system and the production and fire prevention system. The city water supply system is the former's water source.

Water for the TETs's maintenance and drinking needs and the city's hot water supply will come from a river water filtering station that is being built near the TETs.

The source of the production and fire prevention water supply, as is the case with water for engineering needs, is the Svisloch' River.

Maintenance and sewage water and conventionally pure production and rain runoff will be drained by gravity flow into the city sewage system.

The plan specifies the construction on the TETs site of a complex of structures for the neutralization and purification of all polluted production drainage water so that it can be reused. A slime tank is specified for the collection of slimy water.

The following is a list of the basic planned technical and economic indicators of Minsk TETs-4:

Capacity:	
Electrical	780/900 MW
Thermal	4,338 GJ/hr
Allowing for coverage of the city's thermal loads	8,323 GJ/hr
Annual energy output:	
Electricity	4.614 billion kWh
Heat	25.422 million GJ
Specific consumption of conventional fuel for energy released:	
Electricity	211 g/kWh
Heat	4.1 kg/GJ
Cost of released energy:	
Electricity	0.54 kop/kWh
Heat	0.925 rub/GJ
Total estimated cost of construction	151.26 million rubles

Including objects for production purposes (construction and installation work)	133.23 (76.19) million rubles
Specific capital investments in industrial construction as related to capacity:	
900 MW	148 rub/kW
780 MW	171 rub/kW

The estimated and specific costs for the construction of objects for production purposes at Minsk TETs-4 allow for the expenditures (included in Chapter 8 of the combined estimate) for the construction of a regional production assembly base, which was specified for the construction needs of a group of series-produced TETs's; these expenditures total 7.59 million rubles.

Despite the fact that progressive decisions that insure low specific capital investments have been incorporated in the engineering plan, while it was executing the blueprints VNIPIenergoprom's Belorussian Department continued to work to improve the planning decisions for the purpose of an even greater reduction in capital investments, labor expenditures and material utilization, as well as to improve the construction conditions.

As far back as when the engineering plan for Minsk TETs-4 was still in the confirmation process, VNIPIenergoprom's Belorussian Department began to work out a changed master plan for the industrial site that allowed for the new OVK plan, the basic configurational and engineering decisions on which were subsequently used in the realization of a type OVK plan for the TETs-ZIGM series.

In the new OVK plan, the first thing that was done was to combine essentially all the TETs's auxiliary services.

The construction of the OVK made it possible to achieve a sharp reduction in the number of structures on the TETs site (Figure 4a, b), reduce the site's area by 3 ha (10 percent), and also reduce the capital investments (allowing for the reduction in the length of the intrasite communication links) by 300,000 rubles.

During the execution of the blueprints for Minsk TETs-4, it was specified that the TETs-ZIGM plan be used not only for the main building and the OVK, but also for the service building and the circulation pumphouse. The latter was not designed to be built below ground level.

In order to supply heat to the production assembly base (before the introduction of equipment in the TETs), as well as to heat temporary structures and carry out the startup operations at the TETs, the plan specified the installation of five mobile boiler cars. At the suggestion of the TETs's management and the Belenergostroy trust, it was decided to replace the boiler cars with a permanent start-up boiler room with three DKVR-10-13 boilers that run on fuel oil. Practical experience has shown that the use

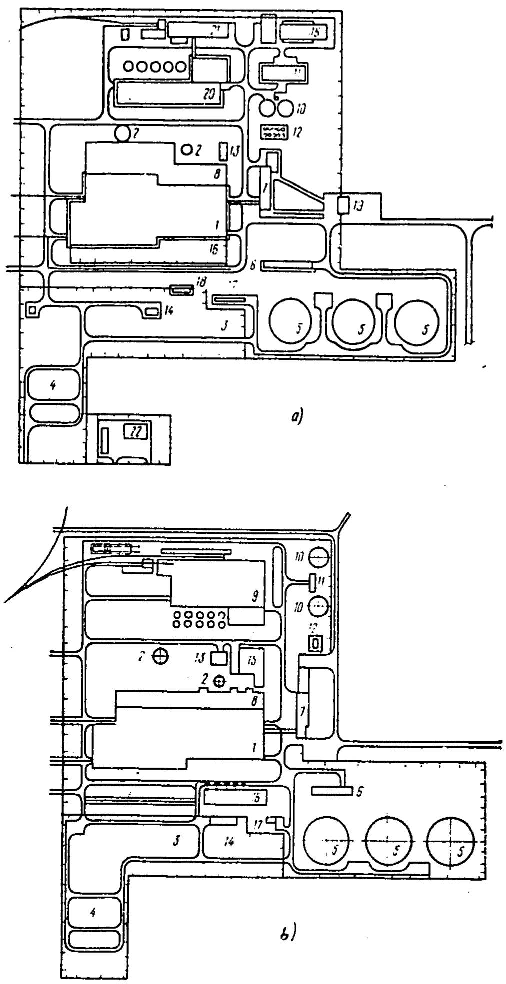


Figure 4. Master plan of the industrial site: a. original; b. changed; 1. main building; 2. smokestacks with gas conduits (H = 180 m); 3. 110-kV ORU; 4. 330-kV ORU; 5. cooling towers; 6. pumphouse for engineering water supply; 7. administrative-service building; 8. open-air area of flue-gas pumps; 9. OVK; 10. hot water storage tanks; 11. pumphouse storage tanks; 12. hydrogen and carbon dioxide receivers; 13. GRP [gas-distributing point]; 14. relay panel area; 15. heating plant pumphouse; 16. outside transformer site; 17. chlorinator room; 18. 10-kV ORU; 19. passageway; 20. chemical water purification shop; 21. chemical reagent storehouse; 22. fire station.

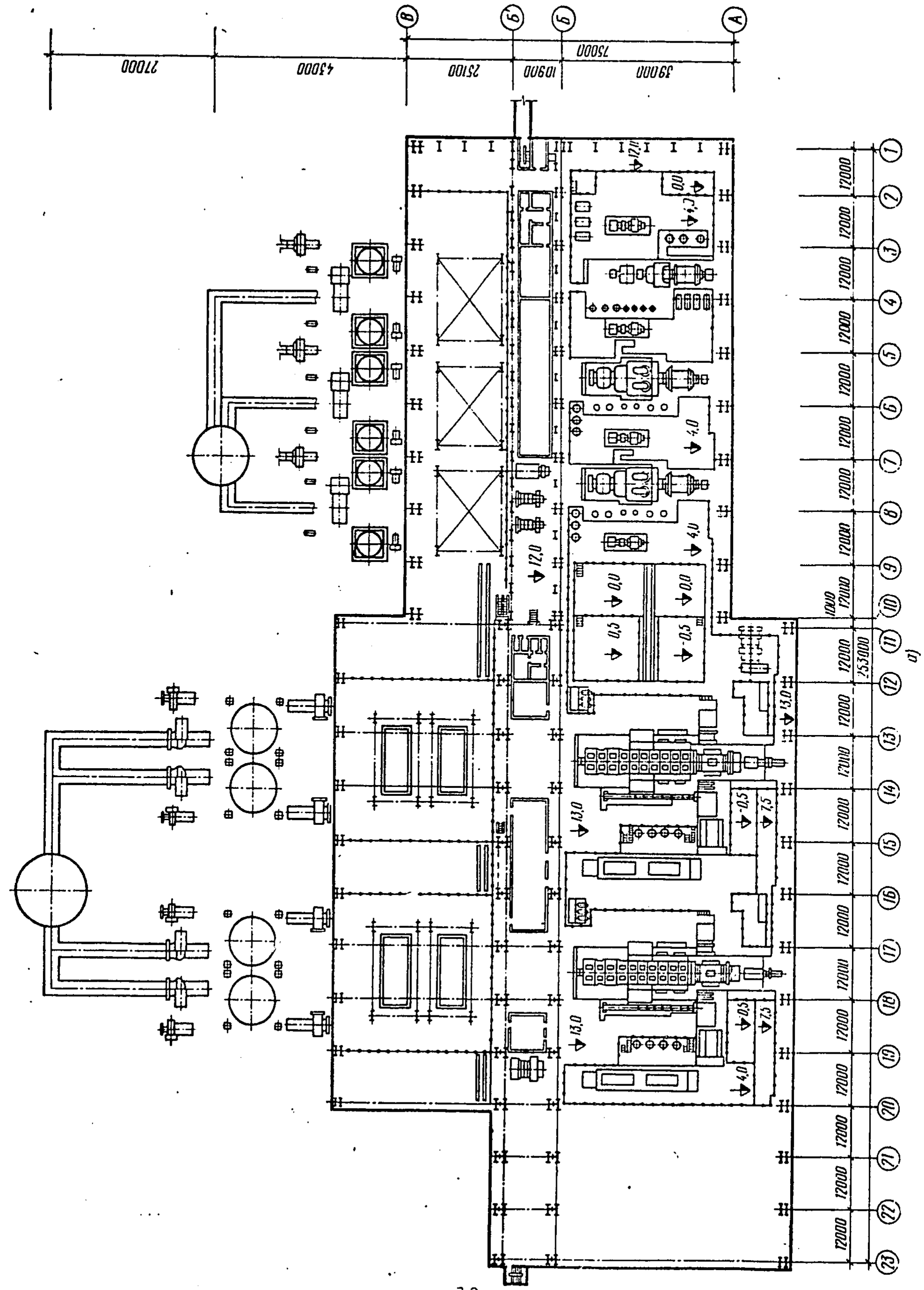
of a start-up boiler room insures a reliable heat supply and also reduces the expenses related to equipment operation and repair.

As a result of the introduction of the new and progressive decisions, as well as a more accurate determination of the project's cost, in the middle of 1979 the estimated cost of the industrial construction was 124.57 million rubles, including 73.34 million rubles for construction and installation work.

The experience gained in planning and building Minsk TETs-4 shows that changing the adopted planning decisions at the stage of blueprint preparation makes it possible to realize an additional reduction in material-intensiveness, labor expenditures and capital investments and to improve the construction conditions.

Features of the Technological Part of the Main Building

Among the special features of Minsk TETs-4 (Figure 5) that affected to a certain degree its choice as the plan-analog for the TETs-ZIGM type plan, we can include the following:



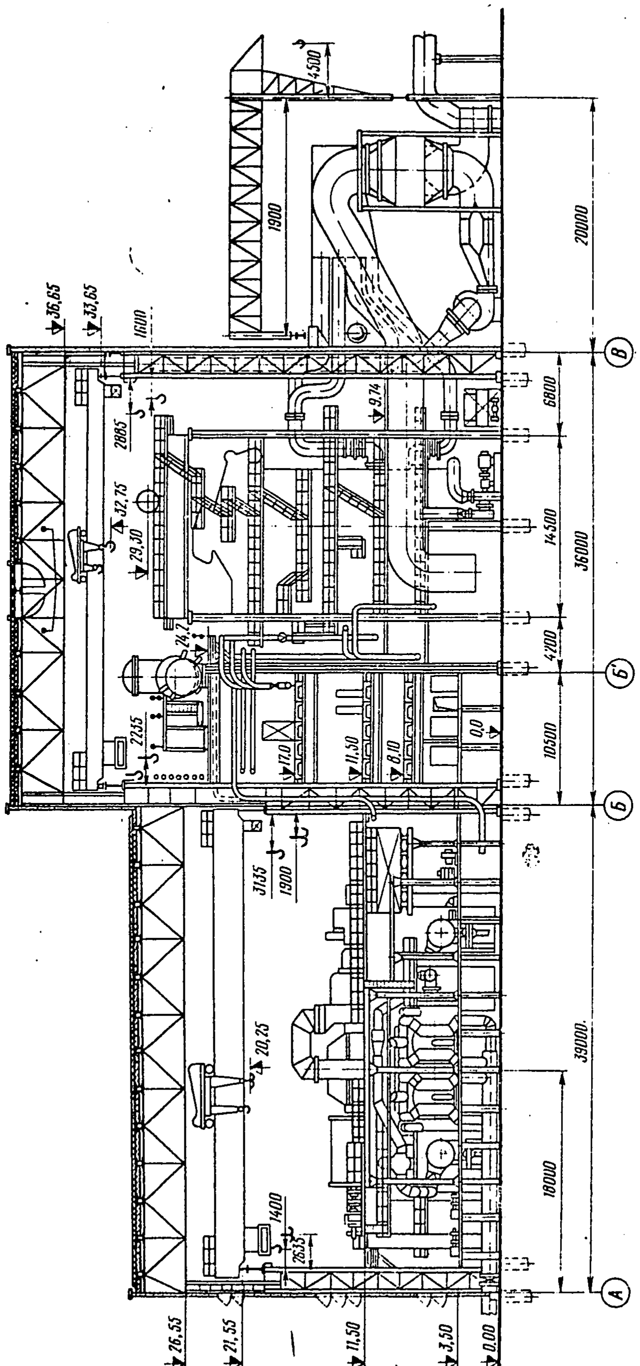


Figure 5. Plan (a) and elevation (b) of the main building.

Minsk TETs-4 is purely a heating plant that was designed without any peak hot-water boilers; the peak thermal loads are taken care of by the four existing regional hot-water boiler units, which are located in the immediate zones where the heat is consumed; the total thermal load covered by TETs-4 and the regional boiler units is 8,400 GJ/hr;
the heat supply system is an open-air one, with an average daily water-level maintenance consumption of about 6,000 t/hr (the storage tanks are located at the regional boiler units, with level maintenance for the networks being carried out at TETs-4, while pressure regulation is performed at the boiler units);
the stepped-up (theoretical) schedule for regulating the temperature of the direct network water (70-180°C) in the TETs's network circuit utilizes transit conduits with the addition of return water before reaching the hot-water boilers in the peak boiler units;
grouping of the auxiliary buildings and structures under one roof.

As is known, the plan for the series-produced gas-and-oil TETs (TETs-ZIGM) was based on the principle of repeated utilization of construction engineering sections with a high degree of plant finishing in any combinations, and with due consideration for the multiplicity of different factors determining the nature and purpose of a TETs.

The sectional principle of construction of the main building, as well as the single type size of the boiler units for the entire project, made it possible to standardize the planning decisions completely and, because of this, to achieve a substantial reduction in the nomenclature for all the auxiliary equipment and piping.

The construction engineering sections were developed on the basis of the installation of turbines of the following types: PT-60-130/10, T-100/120-130, R-50-130/13, PT-135/165-130/15, R-100-130/15 and T-175/210-130. The blueprints were drawn for power sections with PT-60-130/13 and T-110/120-130 turbines, a standard section for the permanent face and a section at the temporary face.

One extremely essential factor that determined the possibility of using the standard plan was the use of modified sections. For instance, a section with a type T-110 turbine can be joined not only to a PT-60 turbine section (Minsk TETs-4), but also to an analogous section and a permanent face section.

The use of construction engineering sections made it possible to accelerate not only the construction and installation of the structural parts and production equipment, but also the planning -- with a corresponding improvement in its quality. For example, the planning of such a critical and labor-intensive assembly as the high-pressure pipelines was basically reduced to dispatching already completed drawings to the producer plant, while matching them with this plant (also an extremely laborious operation that as a rule involves correcting the planning documentation) was reduced to confirming the possibility of using the documentation provided by the standard plan.

The TETs plan was drawn up on the basis of maximum consolidation of assemblies into aggregate units that are completely ready for installation. The size of each unit was determined by the capabilities of the railroad and the lifting machinery used during installation. A unit must contain not only equipment and pipelines, but also fully tested and adjusted fittings. However, the method of installing maximally finished equipment and piping, which in this case consists only of joining large units together, was related to a series of difficulties under the existing procurement conditions; primarily, this meant the unpreparedness of the USSR Ministry of Power and Electrification's KVOIT [possibly auxiliary boiler and turbine equipment] plants to perform such work. This applies to both the production technology and the systems for cost quotation, planning, delivery, metal stocking and so on.

Along with this there are also other difficulties. For example, in addition to low-pressure piping and fittings, the BROU [rapid reduction and cooling] 140/13 aggregate unit contains separate sections of high-pressure pipe (steam and feed water for injection) that are manufactured by BelKZ [possibly Belorussian Boiler Plant] in a general complex of high-pressure tubing. Besides pipes, pumps with electric motors and heaters are part of the aggregate unit of the assembly for heating the untreated water.

The plan specifies the assembly of such units at the production assembly base constructed at Minsk TETs-4's site to service a group of series-produced TETs's. However, the base was not yet in operation by the time equipment installation began.

In connection with this and for a number of other reasons, for all practical purposes it was impossible to achieve the procurement of aggregate units that are completely ready to install for Minsk TETs-4 and other TETs-ZIGM's. The equipment, parts and standard piping units were delivered to the TETs-4 site piecemeal. In the TETs's consolidation and assembly area the parts were assembled into aggregate units and sent to the main building for installation. This installation technique still made it possible to improve the quality of the installation work considerably and to speed up the construction of the TETs. It is necessary to mention here that the metal structures in these units were taken into consideration when calculating the stability of the main building's structural parts.

It was assumed that the greatest difficulties might appear in connection with the joining together of the sections. It was during the implementation of this work that the quality of the plan had to be evaluated and the possibility and feasibility of constructing and installing the main buildings of TETs's using construction engineering sections with a high degree of plant finishing was to be determined.

As is the case at other TETs's being constructed according to the series plan, during the construction and installation of equipment at Minsk TETs-4 the joining together of the sections did not cause any difficulties: the connection of one section to another was no different, for all practical purposes, from the joining together of units in the same section.

It should be mentioned that it is possible to make changes in the developed plan that are related to the specific features of Minsk TETs-4 without any significant reworking of the planning documentation.

For instance, the series-produced TETs plan specifies the installation of two vacuum deaerators (with capacities of 800 and 400 t/hr) as the first deaeration stage for the feed maintenance of the boilers in the section along the permanent face. This decision was based on the necessity of building an industrial-heating TETs with a large steam output. However, the planning documentation was developed in such a fashion that each of the deaerators, with all of its framing pipework, is an independent assembly. This can also be said of the unit for heating untreated water and other assemblies. Consequently, on the basis of the experience gained in using the series-produced TETs plan for Minsk TETs-4, which is purely a heating plant, it can be said that the plan is designed for a rather wide range of different specific conditions.

Nevertheless, while mentioning the virtues of the TETs-ZIGM plan we cannot but also point out its faults. In particular, during the course of the construction we discovered errors and unfortunate decisions for individual assemblies, such as: series connection of the PT-60 turbine's basic boilers with respect to the network water, instead of parallel; the lack of a shutoff valve on the pipe for the production bleeding of steam from the PT-60 turbine; the placement of the continuous purging separator above the tyagodut'yevyye [translation unknown] machines' oil-filling opening, and so on.

Because of the changes and corrections that were made, VNIPIenergoprom had to rework the estimate documentation considerably so as to insure the possibility of using the plan during the installation of the subsequent units and the TETs as a whole.

The decision not to install a standby feed pump, as dictated by the standards of the engineering plan, is making it difficult to determine the objects for the start-up complex of the first power unit. In addition to this, it is impossible to start the first power unit in the presence of two feed pumps (as required by the operators), since the second pump is located in the next section, along with the basic and auxiliary equipment, piping and electrical engineering devices that are organically related to it.

At the suggestion of the installers, a T-shaped connecting pipe with a cut-off fitting and baskets at the pump's intake was manufactured in order to increase the reliability of the feed pump's operation during the start-up of the first power unit. This solution makes it possible to clean the baskets alternately when they become clogged without turning off the feed pump.

In addition to this, it is impossible to use the second power unit until all the equipment in the entire section is installed.

The removal of the network pumps from the main building eliminates the installation in it of peak network heaters, although these heaters could increase the amount of electricity generated at night and on weekends and holidays. The installation in the heating pumphouse of a peak boiler, with steam fed to it and recovery of the condensate, was proposed for Minsk TETs-4.

The use of the series TETs plan for the left component (the permanent face is on the left side) makes it necessary to enlarge the machine room (along one axis).

It should be mentioned that different planning organizations developed the technical documentation for the TETs-ZIGM plan, and although it was created according to unified principles, nevertheless each organization has its own characteristic features that are inherent in its normal work profile. For instance, the Leningrad branch of Orgenergostroy designed the basic piping systems for the machine room and the deaerator section, using the unified system of design documentation (YeSKD), whereas a subdivision of VNIPIenergoprom executed the plan for a permanent face section and the blueprints in accordance with standard for drawings developed by Teploelektroproyekt [All-Union State Institute for the Planning of Electrical Equipment for Heat Engineering Structures]. Naturally, this led to certain difficulties when the installation organizations used the planning documentation.

In conclusion, we should mention that despite the defects we have indicated, the plan for the series gas-and-oil TETs is a progressive one. The reduction in cost, labor expenditures and duration of the construction and installation work depends wholly on the level of the plan and installation preparedness of the equipment, piping systems, electrical engineering devices, KVO [auxiliary boiler equipment] and structural parts, assemblies and elements. In connection with this, the planning documentation for them must be standardized as much as possible and not change over the course of 5-6 years. The development of such documentation must involve the active participation of planners, designers at the plants that supply the equipment and materials, and workers from construction and installation organizations. It is necessary that the work be carried out on the basis of standardization of the composition of the main building and all the auxiliary structures of many TETs's.

Organization of the Construction and Performance of the Work

During the development of the plan for organizing the construction (POS), Minsk TETs-4 was regarded as the leading object of a complex of series-produced TETs's constructed by the continuous method. In connection with this, the organization of a regional production assembly base (PKB), to be used in order to raise the level of installation readiness of equipment, piping systems, electrical engineering devices and structural parts, was specified for the construction site[1]. A new construction control structure that provides for the organization of mobile, mechanized columns was suggested during the compilation of the POS. The numerical composition of the columns and the construction administration for the complex, the volume of residential construction, and the requirements for portable temporary structures for support of the columns were determined on the basis of a network schedule. The expense of acquiring these structures (683,000 rubles) was put into the estimate. The expenditures for construction of the objects at the base (without the cost of the equipment) were included in Chapter 8 of the composite estimate for the TETs.

The PKB's basic indicators, as given in the engineering plan, are:

Area:	
Territory of the base	42.23 ha
Occupied by buildings and structures	142,133 m^2
Roads and hard-surfaced areas	80,420 m^2
Sidewalks	2,940 m^2
Green space	135,000 m^2
Under railroad tracks	24,200 m^2
Length of railroad tracks	6.62 km
Territorial utilization factor	0.82

The PKB included the following objects:
a section for technological metal structures and piping system assemblies;
an assembly-storage unit;
a motor pool with 500 vehicles;
a concrete division, with a proving ground for prefabricated structures and a reinforcement shop;
an emulsion unit (for preparation of waterproof mastics and semifinished products);
a woodworking shop (for manufacturing nonstandard articles and dobornyye [translation unknown] elements);
a section for thermal installation work (assembly and unitizing of units of piping systems and auxiliary equipment);
a section for electrical installation work (production of metal parts used in electrical installation work, completion and assembly of electrical installation articles and automation facilities);
a section for insulation work (chemical coating of the chemical water purification shop's piping system, partial thermal insulation of piping systems, production of metal-coating elements, centralized supplying of thermal insulation materials to consumers).

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[1]In the development of the engineering plan for the production assembly base, the Kiev branch of Orgenergostroy participated in the compilation of the POS.

The estimated cost of the construction and installation work for the objects at the PKB was 8.2 million rubles. The outfitting of the objects with equipment was done by the organizations involved in using them.

In addition to the objects listed above, a number of temporary structures used in the construction of Minsk TETs-4 itself were planned for the base: consolidation and assembly areas, objects in the administrative services complex, roads, engineering networks and so on. The cost of the temporary structures was 2 million rubles.

The decision on the creation of mobile columns and a construction administration for the complex, as proposed in the engineering plan, was not adopted. The construction control structure provided for the enlistment for the construction of the objects of organizations subordinate to the USSR Ministry of Power and Electrification that are located in the Belorussian SSR: the general contractor was the Belenergostroy trust; the subcontractors were the Belenergostroymekhanizatsiya and Belenergomontazh administrations of the same trust, along with subunits of Tsentroenergomontazh [State All-Union Installation Trust of the Main Administration for the Installation of Heat and Power Engineering Equipment in Electric Power Plants] and the Elektrotsentromontazh trust, and the Soyuzenergozashchita association and Gidrospetsstroy [State All-Union Trust for the Reinforcement of Foundations and Structures of the Main Administration for the Construction and Installation of Hydroelectric Power Plants in the Central and Southern Regions]. Organizations from other departments also participated in the construction: the construction trusts of USSR Mingazstroy [Ministry of Construction of Petroleum and Gas Industry Enterprises], USSR Minmontazhspetsstroy [Ministry of Installation and Special Construction Work] and the Belorussian SSR Minmontazhspetsstroy.

In connection with the decision to reduce the number of newly constructed gas-and-oil TETs's, the construction of only those PKB objects that could be used efficiently was stipulated. The dining room, office, UPRK [administration of production and equipment outfitting] warehouses, the auxiliary motor pool building with outside parking, the concrete plant and proving ground, warehouses for electrical materials, paints and varnishes, and the consolidation and assembly areas went into operation in 1976. At the same time, construction work was completed on the building for the production of metal structures, which was intended to manufacture individual nonstandard metal structures and to assemble the spraying units (from asbestos cement) for cooling tower No 1.

On the proving ground of the reinforced concrete parts section, which has a capacity of 10,000 m^3 of articles per year, the production of nonstandard reinforced concrete parts (that also tend to delay construction) needed for Minsk TETs-4 and other Belenergostroy construction projects was organized. Permanent structures that had already been built were used to carry out the installation work on objects of the TETs's first starting complex. For example, the rubber shop was organized in the finished OVK; the metal coatings shop was set up in the same building (in the prirel'sovyy [translation unknown] unit). A permanent shed was built for the storage of heat-insulating materials.

In view of the decision not to organize mobile columns equiped with portable equipment, a permanent domestic-services building for 450 people was erected during the construction process. In addition to this, 20 buses were used to transport the workers from the city to the work site and the dining room. By the time the second power unit was started, the expenses for transporting workers had reached 500,000 rubles.

At the suggestion of the TETs's management it was decided to replace the five PKBM-10/8 mobile boiler cars, which were intended to heat the objects on the base, to provide temporary heating for the permanent TETs structures and to support the start-up operations for the first power unit, with a stationary start-up boiler room with three DKVR-10-13 boilers operating on fuel oil. The boiler room was built according to standard plan 903-1-24/21. The equipment for it was furnished from another project.

In connection with the fact that heating of the main building was not required during the start-up of power boiler No 1 (September 1977), the boiler room's productivity (30 t/hr) proved to be sufficient to support the start-up of boiler No 1 and the production base's needs. The cost of the start-up boiler room was 445,000 rubles (including 298,000 rubles' worth of construction and installation work); according to Orgenergostroy's estimate, the cost of installing the boiler cars (without considering the cost of acquiring them) was 71,000 rubles. Despite the higher cost, however, in the opinion of the TETs's management the construction of the start-up boiler room was preferable: experience in operating boiler cars on other construction projects showed that they are not capable of their certified productivity, are operationally unreliable and require constant repair work. In addition, one man is needed to service each boiler car, whereas one man can service all the boilers in a start-up boiler room. All of the repair work in the start-up boiler room is done in a heated area, using stationary lifting machinery, whereas boiler cars are repaired in the open air. In the authors' opinion, the problems involved in selecting realistic methods for supplying heat to a construction base and for the temporary heating of permanent buildings and the coverage of start-up needs require further study.

The supplying of the construction and installation crews with housing proceeded acccording to plan. Dormitories were built during the first stage: by the time of the maximum concentration of workers at the site (1977), three dormitories with 1,243 beds had been put into operation.

In view of the fact that Minsk TETs-4 is the leading project of the complex of series-produced TETs's, and allowing for the fact that a number of new design decisions were adopted in the plan, facilities for the development of PPR [preliminary work preparation] for the basic objects and assemblies were provided for in the planned work estimate. The development of areawide PPR and PPR for a number of objects was assigned to the principal planner.

Orgenergostroy's Kiev branch did the blueprints for the PKB; PPR for the thermal installation work was the responsibility of the Energomontazhproyekt institute, and for the concreting of the cooling tower's hyperbolic shell it was done by the Gidrospetsproyekt institute.

The list of objects for which PPR had to be developed by the principal planner was discussed beforehand at Belenergostroy. As a rule, that list included areawide objects and also those objects during the planning of which new design decisions were utilized, with particular emphasis on complicated (as far as carrying out the work was concerned) designs. A great deal of attention was given to the planning of assemblies to be constructed by the forces of several organizations (such as the area in the vicinity of the station). In this case, independent implementation of the PPR by the forces of each organization is ineffective, since technological correlation of all the work is necessary. The performance of the excavation work was taken into consideration in the PPR for all objects.

The principal planner developed plans for the temporary structures that were not part of the PKB; the general construction plan for the industrial area at the stage of the construction of the zero cycles; the PPR for the vertical layout, with the overall balance of earth masses, and for the construction of the underground engineering networks, as well as all of the TETs objects inside the construction section; plans for sandy soil quarries. He also corrected the integrated network schedule according to the working drawings and estimates.

The PPR's were developed parallel to the planning of the objects, while the estimates for the excavation work were compiled only on the basis of the PPR's.

The special features of the stratification of the soil at the construction site were taken into consideration during the development of the PPR's. For instance, in places where large masses of sand were encountered at a shallow depth (in the overhead line corridor, for example), quarries were opened. The inexpensive sandy soil was used for the purpose of making the work on the fills and back fills of the foundation pits easier. In the planning of the foundation pits, the ability of loesslike sandy loams to not crumble from vertical slopes was taken into consideration. Experience showed that slanting slopes soon flow under the influence of rain, while vertical banks are more stable. Serious attention was given to methods for draining off surface water.

By agreement with the general contractor, the PPR for the installation of the structures in the ground-level part of the main building were developed allowing for the use of a BK-1000 tower crane. However, at the suggestion of the installation organization, the possibility of assembling the main building with a DEK-50 crane was provided for. On the basis of the results of calculations made in the PPR, the conclusion was reached that it is inadvisable to use a powerful BK-1000 tower crane to assemble the main building of a TETs-ZIGM. In connection with this, the main building of a TETs-ZIGM was assembled with a DEK-50 crane for the first time in power construction.

The construction of the base for the hyperbolic cooling tower in accordance with the PPR confirmed the opinion that the tower's monolithic supporting ring, as well as the sprayer's water distribution standpipe, are extraordinarily inefficient from the viewpoint of production. For instance, for temporary support of the tilted colonnade and for the concreting of the tower's lower support ring, it was necessary to erect scaffolding that required more than 200 m^3 of lumber (or up to 100 t of metal); the casing for the water distribution standpipe is both complicated and laborious.

In the authors' opinion, the organization of the plant production of installable units of metal standpipes is advisable, the moreso if we take into consideration the fact that the increased metal consumption will be insignificant in comparison with the expenditures for reinforcement and numerous foundation parts.

The use of a gang jig (an articulated-frame indicator) that receives, aligns and secures four columns and crossbars was suggested in the PPR for the installation of structures in the personnel services building, which was designed to be built from prefabricated Series II.04 elements. Such devices are widely used in the construction of civil and industrial objects in Minsk. The jig was rented from one of the local construction organizations.

Experience in construction has shown that with the help of one such jig, it is possible to assemble buildings planned for the II.04 series.

The ground level gradient in the OVK building area was about 3 m. The soil was composed of loesslike, dusty loam, with a sandy mass intruding at only one point in the building's foundation. All of the OVK's foundations are of the same depth.

As is known, loesslike soils do not settle, although they do have thixotropic properties (when moistened or acted upon by dynamic effects, they are transformed into a flowing mass). In view of this, during the development of the PPR's it was decided that a sandy bed was needed. In connection with this, the bottom of the foundation pit was realized with a downgrade toward the natural sand mass. The bed's thickness is 0.5-1.3 m.

This decision made it possible to reduce the labor expenditures for the digging of the foundations because manual cleaning of the bottom was not necessary, and also to protect the foundation pit from flooding during heavy winter rains and freezing. The work was performed in full accordance with the PPR.

We should make special mention of the development of the general construction plan for the industrial site and the PPR for the elevation plan, which were worked out at the same time.

The general construction plan was correlated with the elevation plan and took into consideration the order of performance of its work, which specified the construction of communication lines and foundations in fill sections before the elevation work was done. In excavated section, the elevation work was to be done before the construction of those elements. In the development of the PPR, consideration was given to the fact that according to the excavation collation map, partial filling was specified in the center of the area (around the main building). In connection with this, the volume of excavation work on axes 1-10 in the main building's foundation pit was about 5,000 m^3. The amount of work done on the foundations under the other structures, where they were constructed from the black height marks, was also insignificant. The back filling of the foundation pits, as well as the erection of embankments along the underground network corridors and in the area of the assemblies near the station, was done with sandy soil from the local quarry.

The PPR for the elevation plan -- that is, for the large earthen structure, the construction of which was calculated to take a long time -- makes it possible to compile a reliable and convenient (for calculations) estimate for the performance of the excavation work.

The permanent and temporary roads were built with open ditches. The temporary roads, which were designed for a high density of freight traffic and had to last for a long time, were made of monolithic cement concrete on a sandy base; the roads and passageways that were to be used for a short time only were made of prefabricated reinforced concrete slabs; the temporary approaches to the buildings under construction that were not main roads consisted of a layer of crushed stone on sand.

It should be mentioned that as far as the construction conditions were concerned, the PPR for the elevation plan was developed at a time when the question of the layout of the separate communication lines was still not settled and the composite plan of the networks had not been drawn up. However, through the efforts of one planning institute it was easy to correlate the corridors of the future underground networks with the road layout (undesirable disruptions of the road network during the laying of the underground lines were reduced to a minimum).

The experience gained during the construction of Minsk TETs-4 and other objects shows that implementation of the PPR's by the general planning organization makes it possible not only to affect the course of the construction work, but also to follow the realization of the new and progressive engineering solutions and monitor the expenditure of the estimated limit. Besides this, when the construction part of the plan and the PPR's are performed by a single construction organization, the technological feasibility of the documentation is increased and, consequently, labor-intensiveness is reduced and the construction period is shortened.

It should be emphasized that the experience in planning the organization of the construction and performance of the work at Minsk TETs-4, the authors' supervision of the course of the construction work and the constant cooperation of the construction, installation and operating organizations made it possible to improve the quality of this TETs's plan.

The actual excess in the period of construction of Minsk TETs-4 beyond that specified in the POS is explained by the fact that the allocation of capital investments durings the years of construction was, as a rule, below that stipulated by the schedule in the POS. In addition, the engineering plan's decisions on the use of a production base and the organization of mobile mechanized columns was not realized.

Table 2.

Показатель (1)	Годы (2)						
	1971	1972	1973	1974	1975	1976	1977
Объем строительно-монтажных работ, млн. руб. (3)	0,3	1,5	2,9	5,8	5,6	7,3	12,4
Среднегодовая численность работников основного производства (4). . . .	34	168	239	412	475	104	1102

Key:

1. Indicator
2. Years
3. Volume of construction and installation work, millions of rubles
4. Average annual number of basic production workers

The introduction of the first power unit, which was planned for 1975 according to the POS, actually took place in 1977. Therefore, there was an increase in not only the length of the preparatory work, but also in the amount of time required for the basic work. From the beginning of the excavation work on the main building to the start-up of the first power unit it took 35 months instead of the 19 specified by the norms. The dynamics of the development of the volume of construction and installation work and the average annual number of basic production workers are shown in Table 2.

The actual reduction in the labor expenditures in comparison with the standardized ones averages 26 percent, allowing for the added capacity (180 MW), and the specific labor expenditures per kilowatt of installed capacity are 1.93 man-days, including 0.127 man-days on the main building. It should be kept in mind that with the introduction of the first power unit (6.7 percent of the power station's total capacity), 40 percent of the construction and installation work was completed.

Below is a list of the labor expenditures (in man-days) for the work done on objects of the first and second start-up complexes (standard labor expenditures are shown in parentheses):

	First complex		Second complex	
Preparation of construction area.	3,187	(6,919)	405	(616)

	First complex		Second complex	
Internal roads	1,580	(2,563)	426	(692)
Temporary buildings and structures	11,647	(15,038)	307	(466)
Main building	12,481	(20,311)	10,466	(16,166)
Smokestack and gas conduits	1,579	(2,437)	195	(288)
Construction of oil and fuel oil systems	12,788	(2,098)	2,687	(4,016)
Construction of electrical part	2,557	(3,847)	1,668	(2,575)
Construction of engineering water supply	30,860	(48,734)	10,331	(16,347)
Sludge dump and sludge lines	913	(1,857)	363	(593)
Construction of external heat supply, water line and sewage networks	13,102	(22,564)	1,948	(3,045)
Auxiliary production buildings and structures	28,241	(42,691)	11,174	(16,941)
Including:				
OVK	13,669	(20,677)	6,782	(10,161)
Administrative services building	6,964	(11,119)	2,598	(4,082)
Operation and maintenance of machines and mechanisms	14,450	(14,450)	4,397	(4,397)
Transportation in the working zone	5,099	(6,730)	1,900	(2,398)
Auxiliary structures (concrete mortar unit, shops)	49,883	(58,286)	6,853	(7,606)
Maintenance and other systems (transportation, base, storehouses)	77,672	(93,206)	19,746	(22,021)
Measures for accident prevention	1,271	(1,574)	1,103	(1,375)
Assembly and disassembly of construction machinery and mechanisms	714	(979)	302	(307)
Management of area	1,679	(2,545)	3,004	(4,339)
Totals	270,303 (365,721)		77,264 (104,188)	

Note: Work on the construction of the PKB and the concreting of the smokestack's shaft is not allowed for.

Thus, the experience gained in building Minsk TETs-4 according to the TETs-ZIGM plan indicates that the progressive decisions and measures included in it are highly effective. In order to realize these decisions it is necessary to implement organizational and technical measures aimed at increasing the degree of plant finishing of structural parts and engineering equipment and reducing labor expenditures directly on the construction site.

The execution of the PPR's by the general planner is an effective measure that contributes to reducing the labor expenditures and shortening the construction period. In connection with this, it is necessary to enlarge the role of the plan for the organization of construction in every way possible. The planning of the construction must be done in strict accordance with the POS.

Construction of the Basic Structures

In connection with the construction of the main building, erection of the following structural engineering sections was proposed: the permanent face, PT-60 turbine, T-110 turbine (two sections) and the temporary face.

As is known, the series-produced TETs plan specifies increased plant finishing and integrated, section-by-section delivery of structural parts and equipment to the construction site.

In cross-section, the main building is a double-span framework with a built-in deaerator stack. The ceiling trusses in the machine room are joined to the columns by articulated couplings, while in the boiler room they are rigidly attached. The built-in stack is also attached to the basic columns with articulated couplings. Such a design is dictated by the necessity, on the one hand, of insuring sufficient rigidity of the transverse framework and, on the other, of simplifying the assembly work (the articulated joining of the machine rooms's trusses and the stack). Besides this, for convenience in installing the parts, equipment and piping in the deaerator stack with the overhead cranes in the boiler room (in connection with this it was suggested that the installation of the parts coincide in time with that of the piping units), the building's framework must have sufficient load-bearing capability and stability without the built-in stack.

The excavation work for the main building began in September 1974. The foundation pit was dug for axes 1-10 only; that is, for the first three start-up complexes built according to the series TETs plan. The foundation pit was up to 1.5 m deep and the amount of excavation work done was 5,650 m^3.

In view of the fact that the bottom of the foundation pit was composed of loesslike loam, it was filled with a sand and gravel mixture to a depth of 300 mm in order to accommodate the pile-driving unit, while around the perimeter of the foundation pit there was a drainage ditch to collect surface water, which was then removed from the pit by gravity flow.

The main building was designed without a basement. As practical experience has shown, this makes it possible to achieve a considerable reduction in the labor-intensiveness of the construction of the underground part. The foundations underneath the building's shell and the basic equipment consist of driven piles, with a foundation mat depth of 2.3 m. The traditional machine room floor design was changed: instead of a large number of small foundations beneath the stands in the condensation room and the auxiliary equipment in the machine room, the TETs-ZIGM plan uses a solid, monolithic reinforced concrete slab 0.5 m thick (a power floor) that is concreted on a packed sand floor 175 mm thick.

The sandy soil for the floor was delivered from the local quarry, which was about 1 km away. The compaction was carried out with vibrating rollers.

The plan provided for an anchor-type attachment of the parts to the slab. The anchors were placed in holes drilled in the slab and the holes were then filled with epoxy glue.

However, because of a lack of epoxy glue, cement mortar was used when part of the stands were installed at the 4.00 m mark. The experience gained in building Minsk TETs-4 makes it possible to state that the use of power floors reduces the labor-intensiveness of the placement of parts in the underground system by a considerable amount. For instance, 2,084 man-days were expended for the installation of the power slab in one section of Minsk TETs-4, as opposed to the 4.050 man-days that would have been required to install a standard foundation. There was also a decrease in the amount of material consumed. For a single section, the calculated economic effect was 99,300 rubles. Besides this, the power floors were also used as a base for the mobile mechanisms during the assembly of the framework.

In speaking of the advantages of this decision, it should be mentioned that there were also defects in the power floor designs (especially those for the permanent face and PT-60 turbine sections):
the boundaries of the power floors with respect to the sections were not entirely successfully defined, and the use of a grid with working reinforcement in two directions led to reif orcement overconsumption of up to 10 percent (in the T-110 turbine section these flaws were partially eliminated);
the supporting cages (or so-called "frogs") were not planned successfully when the concrete was poured the "frogs" moved apart and the upper grids sand, which led to disruption of the planned dimensions and a reduction in the reinforced concrete slab's load-bearing capacity (after this the designs of the cages were changed).

The main building's framework is metal, the wall enclosure is made of lightweight aggregate concrete panels, and the ceiling is made of integrated panels (shaped, zinc-plated sheet steel with a PSB-S expanded polystyrene heater).

The distinguishing feature of the ceiling in the boiler room is the use of a slotted skylight with a bottom pan for the removal of atmospheric precipitation. The use of a slotted skylight made it possible to reduce the size of the building and make the installation of the roof considerably easier, as the result of a reduction in its height and the bending moments on the building's framework that were the result of wind loads. The roof was made of prefabricated reinforced concrete slabs in which engineering openings and embedded elements were provided for, as was the case with the wall panels.

The execution of the engineering openings at the producer plants contributed to a significant reduction in the amount of manual labor and an improvement in the quality of the construction work. In addition to this, it made it possible to give up having to make individual wall panels from metal frames, with a heater and plastering on laths (as was previously done for the formation of large-diameter openings in the walls).

The improvement in the industrial nature of the articles for the purpose of reducing the labor expenditures at the construction site led to a slight increase in the number of type sizes of the prefabricated reinforced concrete articles.

However, the number of cement forms at the plants was even reduced. For the purpose of comparison, let us examine the number of type sizes of prefabricated reinforced concrete articles for Minsk TETs-4 and for the Mozyrskaya TETs, which was built in 1974 and has a similar cross-section and set of basic equipment (we have eliminated from the comparison the dividing walls and staircase, which at the Mozyrskaya TETs were made of brick): 77 type sizes of cement forms were used to manufacture parts for the Mozyrskaya TETs, while only 66 were used for Minsk TETs-4.

The shaft of the freight elevator was made of prefabricated reinforced concrete elements shaped like sheet steel drums. In comparison with the installation of a brick shaft, the installation of this type of shaft has definite advantages. However, the experience gained in building Minsk TETs-4 shows that a considerable amount of time is spent on welding the inserted parts. In view of this, further improvements in the planning decisions should be directed at reducing the amount of welding work.

The series TETs type plan provides for the installation of a single group panel for two power units. In connection with this, they are placed in one section. Since a total of three power units are being installed at Minsk TETs-4 and the TETs-ZIGM plan does not provide for any further expansion, a single group panel for all three power units was installed at the suggestion of the TETs's management. As a result, the architect's drawings and the designs of the ceilings and partitions were changed.

Besides this, instead of the hydraulic insulation over the group panel using cold asphalt mastic as stipulated in the plan (a standard solution), glued hydraulic insulation made of izol [translation unknown] was used.

It should be mentioned that, for all practical purposes, cold asphalt hydraulic insulation (waterproofing) is not used in TETs construction, despite the fact that such a coating is specified in many plans, is recommended for use by directives, and is extremely efficient, cheap and easy to use. When glued waterproofing is used, however, there is a significant increase in labor expenditures, overconsumption of scarce roofing materials, and an increase in construction cost.

A significant part of the enclosing walls is made from shaped glass. Despite the fact that in the summer of 1978 the wind's velocity head corresponded to Wind Region III according to SNiP [Construction Norms and Regulations] II-6-74 (actually, Minsk belongs in Region I), no deformations or destruction of the glass were detected.

We should mention here the successful arrangement of the stationary metal areas along Row A, which provides the assemblers and installers free access to the points where the panels with the shaped glass are attached.

The metal parts were delivered on a section-by-section basis by a plant belonging to the Energostal'konstruktsiya trust. The shapes of the rolled steel stock were changed at the producer plant. The weight added to the framework in connection with this was 148 t (in three sections).

The plan provided for assembly of the main building's framework without alignment. The installation of the columns' supporting slabs in a fully horizontal position and on the planned elevation mark was to have been accomplished with the help of adjusting screws. Actually, however, the supporting slabs were set up on straightening pads, which undoubtedly had a negative effect on the labor-intensiveness and accuracy of the installation work.

The building's stability is insured by the installation of column braces (according to the plan, they are supposed to installed on axes 6-7; that is, in the middle of the temperature block). In view of the fact that the closure of the permanent face and the inclusion of overhead cranes in the work was planned for the presence of only five axes in the main building, in the PPR the decision was made to install temporary braces on axes 2-3. The standard project drawings should obviously allow for design measures for the installation of temporary braces along axes 2-3.

In the PPR for the assembly of the main building's framework, it was suggested that a BK-1000 tower crane be used. In view of the fact that the volume of work involved in the construction of a TETs-ZIGM main building does not require the full-time use of a tower crane, it was decided not to use one. Construction of the ground-lvel part began in January 1976. The assembly work was performed with crawler-mounted DEK-50, E-2508 and DEK-251 cranes. The DEK-50 crane was used to install five rows of columns. Then the roof was assembled with a tower-jib version of this same crane. The other cranes were occupied with the installation of separate elements, including elements of the deaerator stack and the foundations under the turbogenerators.

The use of the DEK-50 crane for the assembly of the main building led to an increases in labor expenditures. However, both the experience accumulated in installation and assembly work and planning developments show that for the assembly of the structures in the main building of a series TETs with a steel framework, it is most efficient to use a mobile crane, and in particular the crawler-mounted DEK-63 crane that is being created at the present time.

It should be mentioned that back filling of the foundation pit had not been completed by the time assembly of the framework began. Because of an acute shortage of reinforcing steel and cement, the power slab had not been cemented. The cranes were set up on the backing slabs. The temporary rail line had not been completed, either. The structures to be installed were brought in by motor vehicle transport. The consolidation assembly of the columns and trusses was carried out in the installation area. With this mechanization plan, the rate of installation of the framework's first axes was one axis per month.

In the authors' opinion, despite the organizational shortcomings (non-preparedness of the zero cycle, the lack of power floors) and increased labor expenditures for assembly and installation in connection with the impossibility of large-unit installation, the use of mobile, crawler-mounted cranes is preferable to the use of tower cranes. Special emphasis should be given to the fact that during the assembly of Minsk TETs-4's main building, the assemblers managed successfully without being able to use the rail lines. They were completed only by the beginning of the installation of the basic equipment.

The installation of Boiler No 1 began in May 1977. A temporary, movable face that was a three-dimensional crossed-rod structure of the MArkhI type, which is normally used for large-span roofs, was assembled in the main building. This project was carried out by Energostal'proyekt. The tubular rod was connected to a point spherical element containing threaded holes by means of special bolts with pretension. Vertical panels of the sandwich type were used as the face's wall enclosure. The amount of metal consumed in the production and installation of this design's movable face was 100 t instead of the 140 t required to produce the movable face shown in Teploenergoproyekt's drawings (the UIK-01 series).

In view of the fact that the set of elements in the face's grid are extremely intricate in vertical profile, the structure was assembled in large units. In accordance with the PPR, they were lifted into place with two DEK-50 cranes. During the lifting of a unit in the boiler room, the bolts connecting the tubular rods to the angle elements sheared through the sling wires in places. The builders had to strengthen all the assemblies that carried a load during the installation of the crosspieces, as well as the assemblies adjacent to them. An analysis of the causes of the accident showed that the rods in the three-dimensional system and their coupling units were not designed to receive the bending moments arising during the transfer of a consolidated structural unit from a horizontal to a vertical position because of the eccentricity of the unit's mass relative to the points on the sling wires.

Eliminating eccentricity when a block is slung is practically impossible. Besides this, the pinch bolts, which are made of brittle alloyed steel, have already been prestressed during the assembly of the structural units.

It is obvious that the plan for the face requires more work from the viewpoint of its technological assembly and installation qualities. At the same time, the use of such a temporary face design is quite efficient. The structure is delivered to the construction site in compact elements and is light and easy to assemble. The assembly of an installation unit that covers the entire boiler room takes 4-5 days. It is easy to organize openings in such a face. The face itself is also easy to move.

It should be mentioned that the quality of the articles delivered by the plants influenced to a great degree the quality of the work done during the erection of the main building. Very often their quality did not satisfy the standard requirements. In particular, the surface layer of the wall panels was poorly finished, the slabs and panels had cavities, pieces split off and warped surfaces, and carpentry articles arrived at the site unprimed, unpainted and with an increased moisture content.

Despite these flaws, the progressive decisions adopted in the TETs-ZIGM plan made it possible to reduce labor expenditures in comparison with those for the performance of work according to previously used plans. By the moment of the start-up of the second power unit, the labor expenditures for the construction of the main building were 22,950 man-days, including: piling work -- 524; excavation -- 724; assembly, concrete and reinforced concrete work -- 4,360; installation of prefabricated concrete and reinforced concrete designs -- 1,673; installation of metal structures -- 5,524; welding -- 2,589; floor construction -- 1,654. One of the urgent goals during the planning of Minsk TETs-4 was the creation of a consolidated auxiliary building.

The foundations, columns, roof slabs, floor beams and slabs (for the mezzanines), and dividing walls were made of prefabricated reinforced concrete.

For sections requiring considerable area (such as the filtering room), an enlarged column grid measuring 12 x 24 m was used, while in the rest of the building a 6 x 12 m column grid was used for those sections where comparatively small areas for reasons of fire prevention and sanitary and technological requirements. The spans, which were 24 m long, were covered with metal trusses, since the USSR Ministry of Power and Electrification's plants do not manufacture reinforced concrete trusses. The 12-m spans were covered with prefabricated, prestressed reinforced concrete beams.

During the planning process, the decision to install prefabricated reinforced concrete structures was agreed upon with the Belenergostroy trust. As a rule, the elements of prefabricated reinforced concrete articles are used according to the USSR Ministry of Power and Electrification's catalog. Part of the designs are manufactured on the construction site.

During the planning of the engineering part of the chemical water purification shop, which is located in Minsk TETs-4's OVK, one necessity taken into consideration was that of creating standardized sections with increased plant finishing, which under conditions of differences in the quality of the original water, productivity, quantity and quality of the returned condensate, and so on, could be used repeatedly in a certain configuration in both the planned and configurational parts.

The plan stipulates a capability for installing units intended for the preparation of desalinated water in order to make up for condensate losses during production work and in the TETs cycle; the preparation of water for level maintenance in the thermal networks and the outside hot water intake; cleaning of production condensate and condensate from the oil management system; neutralization of washing water from the boilers and water used for acid flushing; preparation and batching of reagents for stabilization of the circulating water; preparation of hydrazine and ammonia solutions for processing the feed water and phosphate solutions for treating the boiler water, as well as equipment conservation solutions; filtration of oily water that has left the flotation units.

The OVK's layout is based on the principle of creating sections for different engineering purposes with transverse positioning of the equipment. This made it possible to construct the water purification building in accordance with the required rates by assembling a different number of units with increased plant finishing for each of the water purification systems.

During the planning process, standard installation diagrams were developed in the form of blank diagrams that are used for most types of water purification. This freed the planners from the necessity of laying out complex and cumbersome diagrams and made it possible to standardize the production equipment and the work needed to install it.

The two-stage desalinization unit, with a capacity of 300 t/hr, was designed to be the "chain" type (completely automated sections). The productivity of a single "chain" is 150 t/hr. Regeneration of all the filters in a single "chain" is carried out simultaneously, upon receipt of a signal indicating depletion of the filtering material in the Stage I anion exchanger.

The use of "chains" makes it possible to create a desalinization unit of any capacity by putting together the appropriate number of standard units.

The installation for the preparation of water for maintenance of the level in the thermal network and the outdoor hot water intake is also in the form of standard units, each with a capacity of 1,000 t/hr.

In the first section of the filtering room's permanent face part, there is a control panel, followed by two blocks of filters for the purification structures and the preserving solution, which are also used without any changes in all gas-and-oil TETs's. The unit for cleaning oily condensate is set up as a separate block of filters. When necessary, the block of filters for removing iron oxides from the condensate can be replaced.

Outside the filtering room there are illuminators, neutralizing tanks and other nonstandard storage tank capacities.

The plan for the chemical reagent storehouse can be used at any TETs without any changes, for all practical purposes; the storehouse for lime, alkali and acid can be expanded. The volume of the storage space makes it possible to store the standard operating volume of reagents, as well as the required reserves of filtering materials. The layout of the storage areas provides a possibility for performing repairs on anticorrosion coatings and the storage of wet lime. The cubicles for the storage of ferric sulfate and common salt are mutually interchangeable.

In the planning of the storehouse, the possibility of maximum industrialization of the construction work was provided for. The foundation level mark under the framework of the building and the elements of the underground system (tunnels, niches, the limestone storage area, reagent cubicles and others) was set at 2.00 m. In the previously used standard and individual OVK plans developed by VNIPIenergoprom and Teploelektroproyekt, the elements of the underground system were set at different levels and were considerably deeper.

Maximum use was made of prefabricated reinforced concrete elements in the framework and the underground system; this made it possible to make extensive use of industrial methods for performing the work.

Monolithic reinforced concrete is specified only for the bottom of the cubicles and for sealing joints. In order to reduce the volume of the foundations, the pumps in the chemical water purification shop were installed in the cable tunnel.

A power floor, which made it possible to install filters and other equipment without foundations, was laid in the OVK's filter room. In addition to this, the use of a power floor made it possible to install different units (depending on the chemical water purification capacity) without changing the structural part.

The prefabricated reinforced concrete annular beams in the upper structure of the foundations beneath the illuminators and the neutralizing tanks, which were used for the first time in the practice of TETs construction, made it possible to reduce labor expenditures significantly, eliminate work done on the installation of complicated annular forms, and improve the quality of the work.

The amounts of building materials used during the construction of the OVK are as follows:

Total consumption of reinforced concrete:	
Prefabricated	5,110 m^3*
Monolithic	1,034 m^3
Total amount of metal structural parts in the building	216 t
Total amount of metal designs used for the production of engineering areas, parts for piping and cable suspension systems, illumination enclosures, monorails, and crane tracks	314 t
Reinforced concrete consumption (per 1 m^3 of building):	
Prefabricated	0.051 m^3
Monolithic	0.0104 m^3
Amount of metal structural parts used per 1 m^3 of building	1.74 kg

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*Including wall panels made of light concrete.

In comparison with the location of production facilities in separate buildings, as was done at Saratov TETs-5 and Volgograd TETs-3, their grouping in the OVK made it possible to reduce the area of the construction site by 18

Table 3.

Показатель (1)	Саратовская ТЭЦ-5 (2)	Волгоградская ТЭЦ-3 (3)	Минская ТЭЦ-4 (4)
Площадь застройки отдельных зданий или ОВК, м²/% (5)	16 803/100	17 304/103	13 800/82,1
(6) Строительный объем, м³/%	148 95[illegible]/100	139 000/93,5	124 000/83,2
(7) Периметр наружных стен, м/%	1 417/100	1 265/90	790/55,9
(8) Площадь наружных стен, м²/%	13 685/100	12 453/95	6682/51
Объем сборного железобетона наземной части, м³/% (9)	6 053/100	7 048/116	4610/76
В том числе ячеистый железобетон (10)	3 271/100	3 114/95	1630/49,8
Расход стали, т (11)	912	1177,6	857,2
В том числе: (12)			
на строительные конструкции (включая монорельсы и подкрановые пути) (13)	185	330,8	304
на сборные железобетонные конструкции надземной части (14)	727,6	843,8	553,2

Key:
1. Indicator
2. Saratov TETs-5
3. Volgograd TETs-3
4. Minsk TETs-4
5. Area of system of separate buildings or OVK, m^2/%
6. Structural volume, m^3/%
7. Perimeter of outer walls, m/%
8. Area of outer walls, m^2/%
9. Amount of prefabricated reinforced concrete in above-ground part, m^3/%
10. Including cellular reinforced concrete
11. Steel consumption, t
12. Including:
13. For structural parts (including monorails and crane
14. For prefabricated reinforced concrete structures in the above-ground section

and 20 percent, respectively, building volume by 10 and 17 percent, prefabricated reinforced concrete consumption by 24 and 40 percent, and steel consumption by 6 and 14 percent (Tables 3 and 4).

In connection with the large relief level gradient and the presence of loesslike soil, the OVK building's foundations were installed on a sandy bed, which made it possible to insure the dryness of the foundation pit and protect the foundation against freezing when the work was being done during the winter.

During the realization of the construction and installation work on the OVK, the obligatory work production technology, as defined by the PPR, was violated. The installation of the structural parts in the above-ground section was begun before the back filling and power floors were completed. The suspended jibs with small compound pulleys, which were specified and should have been used in the assembly work, were not installed in the filtering room. As a result, the installation of the pumps and other equipment was done with block and tackle, which led to an increase in labor expenditures.

Because of the lack of efficient methods for transporting the filters inside the building, the finished floors were installed in the filtering room after the filters were installed, which also led to increased labor expenditures.

The increase in labor expenditures was also affected by the fact that the chemical water purification equipment was deliveried without anticorrosion coatings. The coating of the filters, tanks and batchers and even the trimming of the plant equipment's seams had to be done during installation. The pumps were delivered piecemeal, instead of in aggregate units.

Table 4.

Показатель на 1 МВт установленной мощности (1)	Саратовская ТЭЦ-5 (480 МВт) (2)	Волгоградская ТЭЦ-3 (450 МВт) (3)	Таллинская ТЭЦ-2 (460 МВт) (4)	Минская ТЭЦ-4 (435 МВт) (5)	Минская ТЭЦ-4 при расширении (до 900 МВт) (6)
Строительный объем, $м^3$ (7)	312	309	279	285	138
(8) Площадь застройки, $м^2$	35	38,6	32,2	31,8	15,3
Расход сборного железобетона и бетона, $м^3$ (9)	12,6	15,6	10,6	11,7	5,7
(10) Расход стали, т	1,99	2,48	2,16	1,95	0,95

Key:
1. Indicator per 1 MW of installed capacity
2. Saratov TETs-5 (480 MW)
3. Volgograd TETs-3 (450 MW)
4. Tallin TETs-2 (460 MW)
5. Minsk TETs-4 (435 MW)
6. Minsk TETs-4 after expansion (to 900 MW)
7. Structural volume, m^3
8. Area of structure, m^2
9. Prefabricated reinforced concrete and concrete consumption, m^3
10. Steel consumption, t

A DEK-251 crane was used to assemble the double-span filtering room. The structures in the production and service part of the OVK were installed with the help of the same crane and different holding devices.

Unfortunately, there were departures from the plan during the performance of the zero-cycle work, which led to overconsumption of materials and increased labor expenditures. In particular, the overflow channel was shifted (by 1 m) and the elevation mark of the cable tunnel on which the pumps were to be installed (according to the plan) was raised (to 40 cm). This, in turn, caused difficulties during the installation of the pumps, since it was necessary to preserve the planned elevation marks of the piping systems at the intake. In addition to this, the progressive decisions contained in the plan were not used because of the refusal of the plants that manufactured the reinforced concrete designs to produce part of the articles. For instance, the plan specified the installation of light aggregate concrete wall panels in the lime management area. The choice of these panels was caused by the high moisture content of the air during the slaking of lime by the open-air method. Such designs are manufactured by the USSR Ministry of Industrial Construction's plants, although Energostroykonstruktsiya [Trust of the Main Administration of Plants and Production Bases of the Construction Industry, USSR Ministry of Power and Electrification] refused to manufacture them.

The were no other deviations from the engineering part of the plan: the "chains" of equipment in the filtering room were collected in production sections. However, the desalinization "chain" was put into operation without preliminary cleaning, despite the fact that this did not insure normal operating conditions.

In noting the defects in the construction of the OVK that were the result of various causes, we must say that the experience gained in planning and building the OVK demonstrated the correctness of the layout and structural decisions that were made.

We should regard as another successful decision the one to install overhead lights in the filtering room, since their production and installation did not cause any difficulties and their operation during the winter confirmed their reliability. The installation of integrated ceiling panels played a positive role in reducing labor expenditures.

The basic decisions adopted in the plan for Minsk TETs-4's OVK were used to develop a standard OVK plan for the TETs-ZIGM series. In this plan, a final decision was made to divide the OVK into construction engineering sections: a permanent face unit, a filtering room section and a chemical reagent storehouse section.

The filtering room's two 24-m spans with metal trusses were replaced with 12-m spans covered with prefabricated reinforced concrete beams. In addition, the permanent face unit now includes a laundry, the anticorrosion coating shop and the solvent unit, which were to be located in a separate building according to the Minsk TETs-4 plan. At the same time, the absence of many prefabricated reinforced concrete elements in the USSR Ministry of Power and Electrification's catalog frequently led to overconsumption of materials and an increase in the cost of the work. In connection with this, it is necessary to speed up the publication of a new catalog of prefabricated reinforced concrete designs and articles for thermal electric power stations and to include in it new and economical designs of a union-wide nomenclature, and in as short a time as possible to begin producing them at the ministry's plants.

The first stage of Minsk TETs-4's construction provides for the erection of a fuel oil storage area with four ground-level metal storage tanks that are each capable of holding 20,000 m^3. In the course of geological engineering studies performed within the limits of the compressed strata under the foundations of two of the storage tanks (at depths of 5-16 m), deposits of peat and peaty soil were discovered. This soil occurs with cross-bedding. The peat layer's thickness reaches 6 m (Figure 6). The soils' physical properties are presented in Table 5.

Table 5.

Показатель (1)	Лессовидные супеси (2)	Заторфованные грунты и торф (3)
Плотность, т/м³ (4)	2	1,2
Коэффициент пористости E (5)	0,6	2,57
Консистенция B (6)	0,5	—
(7) Сцепление C, МПа	0,021	0,024
Угол внутреннего трения (8)	29°	—
(9) Модуль деформации, МПа	7	2

Key:
1. Indicator
2. Loesslike sandy loams
3. Peaty soil and peat
4. Density, t/m^3
5. Porosity factor E
6. Consistency B
7. Cohesion C, MPa
8. Angle of internal friction
9. Modulus of deformation, MPa

Considering the rigid requirements for the permissible settling of storage tanks in the presence of peat and the nonuniform occurrence of silty loams with a modulus of deformation of 7 MPa in their foundations, a plan for a piling foundation for the two tanks was developed initially.

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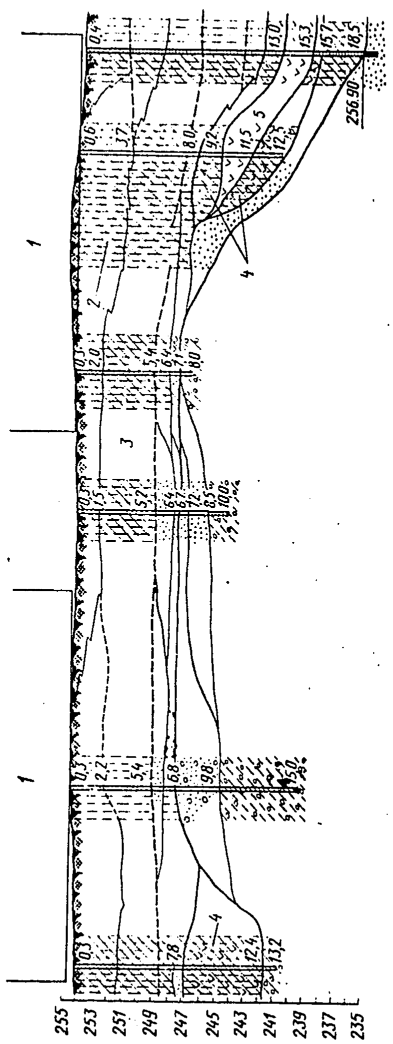

Figure 6. Geological engineering profile beneath fuel oil storage tanks: 1. storage tank; 2. loesslike sandy loam; 3. loesslike loam; 4. peaty loesslike sandy loam; 5. peat.

In connection with this, the length of the pilings had to be determined by test sinkings, since the bedding of the soil did not allow the necessary piling depth to be determined with sufficient accuracy.

Keeping in mind the high cost and material- and labor-intensiveness involved in erecting a piling foundation with composite (because of their great length) pilings, simultaneously with this variant we worked out one for strengthening the foundation with installation of the storage tanks without the use of pilings. The results of the additional soil studies, which demonstrated the possibility of compacting the soil during preparation of the foundation for the construction of the tanks, were used during preliminary compression of the soil by artificial loading (with a soil cone 8 m tall).

After 4 months of aging, this area was utilized in the site's elevation plan. The amount of fill was 38,000 m^3. The filling was done with local soil from as far as 1 km away. The fill was leveled with bulldozers.

Datum marks were set up so that the settling of the foundation could be observed during the filling process. As a result of the compression, the foundation settled from 70 to 176 mm (Figure 7).

The rejection of the piling foundation eliminated the necessity of constructing a monolithic reinforced concrete foundation mat with a volume of 1,560 m^3 and the driving of 1,400 m^3 of pilings and made it possible to save 1,200 t of cement and 210 t of reinforcement. The labor expenditures were reduced by 5,200 man-days and the capital investments by 200,000 rubles. Besides this, this decision made it possible to shorten the length of the construction process.

In conclusion we should mention that our experiences in using the standard TETs-ZIGM series plan for the main building of Minsk TETs-4 demonstrated the undoubted progressiveness and economic effectiveness of the decisions embodied in it. The use of construction engineering sections made it possible to simplify the development of the planning estimate documentation and the completion and delivery of parts and equipment to the construction site. The repetition of the planning decisions for a number of TETs's that are under construction made it possible to take into consideration the experience gained during the construction of the leading projects (Minsk TETs-4, in particular) and, on this basis, to improve the quality of the construction work).

Power Supply Systems

As is known, in the development of a plan for a modern TETs, the choice of the plan for the working and reserve power supply for the plant's own needs is one of the most important problems to be solved.

One specific feature of the production process in an electric power station is the necessity of maintaining constant dynamic equilibrium between the

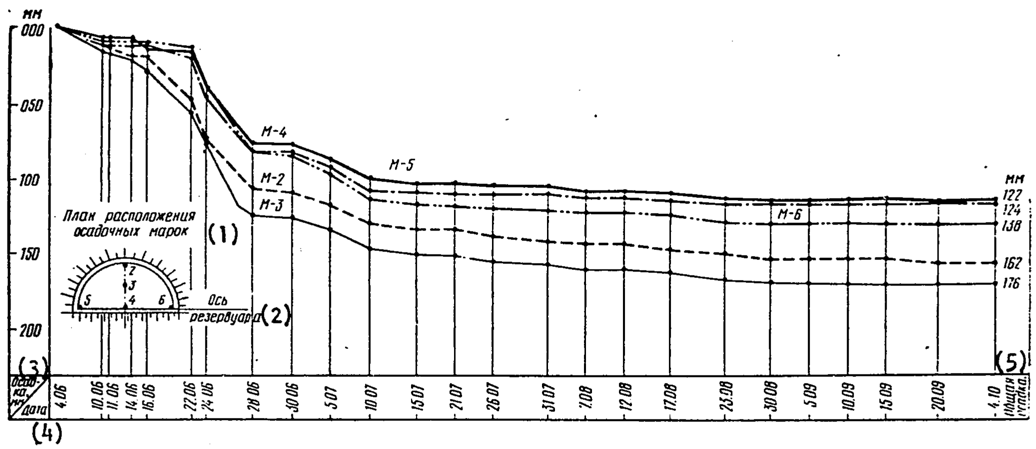

Figure 7. Graph of soil settling under fuel oil storage tank fill (M-2, -3, -4, -5, -6 = marks).

Key:

1. Plan of distribution of settling marks
2. Axis of storage tank
3. Settling, mm
4. Date
5. Total settling

output and consumption of electricity, which causes a certain instability in the operating conditions for thermal electric power stations and even greater instability in those for stations that are also used to supply heat for district systems. Disruption of this equilibrium inevitably entails a change in the most important parameters of the power system's regime, which are the ones characterizing the quality of the electric power supply to the consumers.

In view of this, the parameters and configuration of the working and reserve power supply systems for the plant's intrinsic needs must insure a reliable and uninterrupted supply of electricity to the critical mechanisms under both normal and emergency conditions.

Both in our country and abroad, certain principles for the construction of power supply systems that insure a high degree of reliability and uninterruptedness in the supply of electricity for a power station's own needs are used in the planning process at the present time. The main ones are:
under normal conditions, the critical mechanisms of any aggregate unit in the power station must obtain their electricity from their own generator; supplying the mechanisms in any power unit with electricity from a neighboring power unit is undesirable under normal conditions (an exception can be the reserve mechanisms of intrinsic consumption intended for the normal stopping of a power unit in an emergency situation);
in addition to the working supply, every section that feeds the critical mechanisms of a power unit should be provided with a reserve supply that cuts in automatically;
it is advisable to connect the reserve source of electricity to outside power sources that are capable of preserving their ability to operate under emergency conditions;
during brief interruptions in the supply of electricity for intrinsic needs, the subsequent group self-starting of the critical mechanisms of the system for intrinsic needs must be insured.

Besides this, the configuration of the system for the working and reserve power supply for intrinsic needs depends on the configuration of the main electrical circuit diagram for each specific electric power station.

During the development of the plan for Minsk TETs-4, we examined several variants of the system for the working and reserve power supply for intrinsic needs. It should be mentioned that because of the diversity of the equipment that was to be installed, it was difficult to select the optimum system to supply Minsk TETs-4's intrinsic needs.

For the first part of the TETs, we adopted the following plan for the working and reserve power supply for the plant's intrinsic needs.

The working supply for the intrinsic needs of the first and second turbounits is provided from the first power unit's generator circuits, by a reaction otpayka [translation unknown] that is connected between a cutout in the generator's circuit and the power unit's step-up transformer. The working voltage for the intrinsic needs of the third unit and the next two is provided through step-down transformers, by a system of otpayki, from the generator circuits themselves, while the reserve supply for the intrinsic needs of the first three TETs units comes through a 10.5/6.3-6.3 kV step-down transformer with a capacity of 25 MV·A that is connected by an otpayka to the generator circuits of the second turbounit, in the circuits of which there is an oil circuit-breaker.

Circuit-breakers have not been installed in the circuits of the generators of power units Nos 4 and 5 because of their considerable cost and inadequate reliability. A 63 MV·A step-down transformer connected to the 110-kV ORU buses is provided to back up the power supply for the intrinsic needs of these two power units. There is no specified connection between the reserve conductors of the block and nonblock parts. For the future expansion of the TETs, it has been suggested that an additional reserve transformer with a capacity of 40-65 MV·A be installed. The supply for this transformer will be taken from the tertiary winding of the 200-MV·A autotransformer that connects the 110- and 330-kV buses.

At the present time, the first two power units have been installed at the TETs and are in operation. The experience gained in installing them and adjusting their electrical parts showed that long before the basic equipment is put into operation in a TETs, it is necessary to have a powerful source of electricity in order to test and run-in the basic mechanisms of the supply system for the intrinsic needs. Otherwise, the introduction of the station into operation can be delayed.

For instance, an additional 5,600-kV·A transformer that was not specified by the plan was installed at Minsk TETs-4 by a decision of Belglavenergo. This made it possible to begin testing the intrinsic consumption mechanisms before the introduction into operation of the basic equipment (by approximately 1.5 months) and to eliminate any problems that were discovered on a timely basis. In the authors' opinion, the functions of this run-in transformer could have been performed successfully by a separate reserve transformer for the TETs's intrinsic needs that receives power from the 110-kV ORU buses. The installation of a reserve intrinsic needs transformer at the TETs ahead of time would have made it possible to avoid unnecessary expenditures of working time and material means for the installation and adjustment of the temporary setup.

Besides this, the lack of a separate reserve transformer at the TETs site can complicate the operation of the project during the initial period and create a threat of the appearance of emergency situations both in the TETs itself and in the thermal networks supplied by the given electric power station.

It should be mentioned that the connection of a reserve transformer to any power unit by an otpayka lowers the power station's operational reliability.

Powering the reserve transformer by an otpayka from the generator circuits of any power unit can also lead to a situation where the working voltage for the given unit's intrinsic needs has to be obtained from the TETs's other power units. In connection with this, there may be a reduction in the object's operational reliability and the appearance of an emergency situation with the simultaneous removal from operation of two power units. Thus, considering the significant capacities of modern heating plant units and the percentage of their participation in the supplying of heat and electricity to consumers, systems for supplying working power for the intrinsic needs of two power units from a single otpayechnyy [translation unknown] should not be combined.

During the development of the general plan for Minsk TETs-4, the combination and rational placement of different types of services in a single building was provided for.

In connection with this, questions having to do with the power supply were also taken into consideration.

A study of the composition of the OVK's users showed that the structures for them can be divided into two groups.

The structures in the first group are built and put into operation simultaneously with the start-up of the first power unit, with their further expansion not being assumed.

Structures belonging to the second group of users are put into operation on a stage-by-stage basis and are enlarged as the TETs's basic production increases.

In order to supply power to these users, four operating power transformers (6/0.4 kV) and one reserve transformer have been installed. The capacity of each transformer is 1,000 kV·A. The 0.4-kV panel consists of 0.5-kV KRU cells that are located in the 0.4-kV RU's area and the chemical water purification shop's filtering room.

The 0.5-kV KRU cells in the filtering room are powered with the help of two trunk conductors. The other 0.5-kV KRU cells are connected directly to a transformer in the 0.4-kV RU area.

The conductors in the filtering room are run on supports above the KRU cells, along a group of pumps that has been specially installed in a single row in the room.

During the future expansion of the chemical water purification shop, this decision will make it possible to solve the problem of powering the next groups of pumps very easily (the conductors will be lengthened and additional groups of cells will be installed).

A ShMA-68 bus wire was used as the conductor. In order to improve the conditions for starting the powerful electric motors in the chemical water purification shop's filtering room, the conductor with the lowest reactance was chosen. However, the use of such conductors resulted in a significant increase in short-circuit currents, which made it more difficult to select the switching equipment used in the system for starting the small motors powered by them[1]. In view of this fact, a number of the cases containing switching equipment that were located in the filtering room were connected not to the conductors, but -- with the help of cables -- to the buses of the 0.4-kV RU sections.

The placement of the 0.5-kV KRU cells in the filtering room made it possible to avoid the installation of additional cases with equipment for controlling the motors, since the instruments for monitoring and controlling the electric motors are located on the front sides of the 0.5-kV KRU plant cells.

For the purpose of maximum simplification of the design of the filtering room's floors, most of the mechanisms have been placed in the electric cable tunnel. This decision made it possible to simplify the connection of the power cables to the electric motors and eliminate the laying of a large of gas pipes in the floor. However, experience in constructing the operating the OVK showed that the use of the cable tunnel in the filtering room as foundation is ineffective, since it is impossible to prevent its penetration by a significant amount of chemically aggressive water; it is necessary to install an expensive and complicated fire extinguishing system. In addition to this, a small number of cables are laid when the conductors are in the cable tunnel.

The placement of a cable tunnel in the filtering room was not provided for during the development of the plan for the series TETs's OVK. The laying of the control and several power cables from the cases with the switching equipment to the chemical water purification shop's control panel was realized with a suspended cable duct along the wall of Row A inside the room. Conductors were run along this same wall, while the cases with the sw ching equipment were installed beneath them in areas raised above floor level by 0.8 m. The pumps and motors were installed directly on the filtering room's power floor. The motors were connected to the switching equipment by an APV [automatic reclosing] wire that was laid through pipes placed in the finished floor's concrete layer. It should be mentioned that in this case it is advisable to use motors with top-mounted input boxes, which -- unfortunately -- are not produced in sufficient quantities by Soviet industry.

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[1]The results of calculations showed that when cases with AZ100 automatic units are connected directly to the conductors at a distance of less than 30-35 m from the RU buses, the automatic units are not resistant to the effect of short-circuit currents.

The experience gained in planning and installing the power section of the OVK showed that the adopted system for the underground introduction of cable in the filtering room of the chemical water purification shop provides a reliable and economical power supply and makes it possible to standardize the planning decisions. However, the making up of sets of power objects with conductors of the ShMA type is not organized efficiently enough. These conductors are produced only by plants belonging to USSR Minmontazhspetsstroy. In the conductor production parts list there are no sections and assemblies for direct connections to 0.5-kV KRU and KTPSH-0.5 cells. As a result of this, some assemblies are fabricated on the spot, which comlicates the installation process, reduces reliability and causes the esthetic qualities of the design to deteriorate.

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ELECTRIC POWER AND POWER EQUIPMENT

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INSTALLING THE 100-MW POWER UNIT AT MINSK TETS-4

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 10, Oct 79 pp 20-21

[Article by B.I. Kagan, engineer]

[Text] Power unit No 2, which was installed at Minsk TETs-4 with a capacity of 100 MW, consists of a gasproof BKZ-420-140 NGM-4 boiler and a T-100/120-130-3 turbine with a TVF-120-2 generator.

Before the boiler was installed, the pieces it was shipped in, the firebox panels and the side panels of the convection shaft were consolidated into installation units on the assembly floor, which is equipped with KS-50-42 cranes with a lifting capacity of 50 t. Assembly was also done with the help of the two 30-t bridge cranes in the boiler room: the panels of the side (along with the stiffening collars) and rear screens into one installation unit; the lower (together with the burners) and upper panels of the front screen into three and seven units, respectively; the three shipping units of the convection shaft's rear wall into one installation unit. Only the welding of one band of pipe (60 x 6 mm) joints at the 21.00 m level on the front screen was carried out in the installation area. The side panels of the convective heating surfaces were assembled into 12 installation units (with two shipping units in each) that were then set upright between the beams of the ceiling and placed in the planned position on their permanent supports.

In accordance with the PPR [work plan] specified by the Leningrad branch of the Energomontazhproyekt institute and SNiP [construction norms and regulations] III.G-11-70, the 98-t boiler shell was lifted with the help of special rigging and a 40-t counterweight. Only the technology for using two 30-t overhead cranes to lift a 100-t shell from its original position, along the front of the boiler to its overhead covering was developed in the PPR; the problems involved in placing the shell in the original position and moving it into its planned position relative to the overhead covering were not discussed.

The installation of the boiler shell was carried out in accordance with the PPR and the requirements of SNiP III.G-11-70 in the following sequence.

A bridge with a temporarily attached slide block was installed on beams that were preliminarily welded to a column along the boiler's axis in Row B of the main building and to plugs placed in the boiler's overhead covering. The lifting cable was taken in, in the grooves of its blocks, up to the bridge's hoist. After this, the counterweight was lifted by the cranes and fastened by its sling to the metal parts of the bridge. One loop of the lifting cable was attached to the crossbar, from which the shell had previously been suspended. After the counterweight was raised 200 mm by the overhead cranes, the sling was removed and replaced with the lifting cable. The shell was then slung from the hooks of the overhead cranes and lifting began as the counterweight simultaneously began to sink. The lifting of the shell to the upper mark took 35 minutes. After the shell was lowered onto the boiler's overhead covering, the bridge cranes' hooks were unslung. The counterweight was then lowered to the zero mark and the plugs and the bridge with the slide block were dismantled. After it was placed in the planned position on the boiler's overhead covering, the shell was positioned precisely with the help of jacks and rollers. The installation of the block-and-tackle system and the hoisting of the shell and its placement in the planned position was carried out in three work shifts requiring a total of 33 man-days.

This assembly method is quite efficient. The total labor expenditures for the installation of the BKZ-420-140 NGM-4 for power unit No 2 were 8,826 man-days. The significant reduction (by 2,365 man-days) in the standard indicators was achieved by reducing the number of installation units through consolidation on the assembly floor, efficient organization of the work, and the use of highly qualified assemblers and installers.

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ELECTRIC POWER AND POWER EQUIPMENT

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PROBLEMS AND WAYS OF IMPROVING FITTING AND INSULATOR PRODUCTION DISCUSSED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 10, Oct 79 pp 21-23

[Article by I.V. Dubov, engineer: "Problems and Ways of Improving Fitting and Insulator Production"[1]]

[Text] The prospective plans for increased electricity output have determined the necessity of developing various branches of this country's national economy, and in particular the fitting and insulator subbranch. In connection with this, the production capacities of the plants producing high-voltage line insulators and fittings must be developed as rapidly as possible.

Calculations show that in the near future the requirements for fitting and insulator output will increase by a factor of about 1.5. The satisfaction of all the national economy's needs for insulators and fittings and the timely delivery of them to power projects that are under construction or already in operation is the basic goal that USSR Minenergo [Ministry of Power and Electrification] has set for the Elektroset'izolyatsiya trust, which consists of plants and enterprises as well as scientific research and planning organizations.

The attainment of this goal is impossible without constant improvement of the production output and its technical and economic characteristics, an increased degree of installation readiness and operational reliability, the introduction of new and progressive production processes using modern, highly productive equipment, the use of automatic systems for controlling

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[1] Providing power supply network construction with line fittings and insulators is an urgent problem. In this set of articles prepared by the Elektroset'izolyatsiya trust and offered for the reader's attention, there is a discussion of the basic directions for improving the fitting and insulator subbranch and a listing of new line fittings and insulator designs, the introduction of which will make it possible to improve the efficiency and quality of the power supply network construction process (Editorial Board).

production and monitoring the quality of the production output, a constant increase in the productivity of labor and the freeing of workers engaged in difficult and low-efficiency operations, and the development and implementation of measures to protect the environment.

For many years the plants and other subunits of Elektroset'izolyatsiya have filled the needs of the national economy for insulators and fittings. For instance, from 1971 to 1978 fitting production increased by 280 percent and insulator production by 30 percent. By the end of 1980, however, the production reserves that previously existed will be completely exhausted and a slight deficit in capacity will emerge by the beginning of the 11th Five-Year Plan.

This situation is explained by imperfect planning of the rates and volumes of development of fitting and insulator production in the past. The rather powerful production base that was created for the output of insulators (glass ones, in particular) was determined by the development of metal production. As a result, the output insulator parts turned out to be unbalanced with the output of cast iron caps, as well as high-voltage fittings. In metal production, and particularly in casting and porcelain production, reorganization with the replacement of obsolete and worn-out equipment was not conducted on a timely basis. For instance, USSR Minenergo's GlavPEU [Main Administration for Economic Planning] allocated a total of only 4.8 million rubles for the modernization and re-equipping of the fitting and insulator subbranch's leading plants (the Slavyansk and Yuzhno-Ural'sk fitting and insulator plants and the Khartsyzsk cast fittings plant) over the last 3 years. Besides this, for a long time the increase in production output at fitting and insulator plants was planned without allowing for the necessity of developing auxiliary shops and services (such as tool and repair), as well as subunits charged with solving the prospective problems of mechanization and automation of the production processes.

At the present time, Elektroset'izolyatsiya has developed technical and economic proposals for the future development of enterprises in the fitting and insulator subbranch that feature both extensive and intensive methods.

The first development method provides for the construction of new plants and shops at existing enterprises. Since 1976 the Tula high-voltage fitting plant has been under construction; its first stage (the cast iron foundry) should go into operation in 1981. In the near future, construction of a production base in the settlement of Belyy Rast will begin. At this base, the production of polymer line insulators and rigid leads for the outside distributing devices of 110-500 kV substations will be organized under plant conditions for the first time. The planning of a new plant for glass insulators began in 1979. Construction of a new shop for glass insulators for ultrahigh-voltage power transmission lines is being completed at the L'vov insulator plant. USSR Minenergo has also approved the plan for the construction of new shops at other existing enterprises belonging to Elektroset'izolyatsiya.

The second development method specifies an intensive increase in the capacity of fitting and insulator production facilities by re-equipping and modernizing existing shops.

The introduction of the proposals that have been developed will make it possible to increase insulator production capacity by more than 40 percent, casting production by 65 percent, and line fitting output by 30 percent. In connection with this, the disproportion between the insulator and casting production capacities that has been mentioned will be eliminated and reserves for further increasing the capacities will be provided.

However, it should be mentioned that the trust cannot independently solve all of the problems on the development and modernization of enterprises with which it is faced. The assistance of the functional administrations and leadership of USSR Minenergo is needed.

For a long time the problems of the development of plants belonging to the fitting and insulator industry were not understood by GlavPEU and GPTUS, the organizations that do the prospective planning for power construction. As a result, none of the decisions prepared by the regulatory agencies in this country has provided for the development of fitting and insulator production.

The means that have been allocated are inadequate for the construction of new and the modernization of existing fitting and insulator plants. At the same time, the forces available in the trust's construction organizations are not capable of realizing even these facilities in the periods of time set by USSR Gosstroy.

USSR Minenergo, which has at its disposal powerful construction organizations and builds the most diversified industrial and residential projects, is not offering the assistance needed for the construction of fitting and insulator plants. In individual cases, the main construction administrations act as subcontractors and do build such plants, although the rates of construction (particularly in Glavatomenergostroy [possibly Main Administration for Atomic Power Station Construction] and Glavteploenergomontazh [Main Administration for the Installation of Heat and Power Engineering Equipment in Electric Power Plants]) are not up to the norms.

Elektroset'izolyatsiya, which is the only manufacturer and supplier of fitting and insulator output in the country and does not have production reserves, cannot stop the operation of its shops -- much less its plants -- in order to carry out re-equipping and modernization, the need for which at the present time is obvious. This fact has not been taken into consideration by USSR Minenergo's planning agencies.

Special equipment and monitoring and testing instruments, part of which are not even manufactured in this country, are needed for the re-equipping of fitting and insulator plants and the organization of the production output process on a modern level. In addition to this, special silicate, chemical and heat-resistant materials are needed, as well as electrosmelted refractory bricks, structural and alloyed metals and high-grade cements. The trust must be supplied with such equipment and materials, on a centralized basis, by Glavsnab [Main Supply Administration] and Glavenergokomplekt [Main Administration for Insuring the Supply of Complete Sets of Power Engineering Equipment of Electric Power Plants, Substations and Networks]. Since the rest of the organizations belonging to USSR Minenergo do not use them, neither Glavsnab nor Glavenergokomplekt gives the necessary attention to this problem.

The existing planning system, in which the results of the plants' activities are expressed in tons of finished insulators and cast iron fittings, is hindering the further development of production facilities and an increase in fitting and insulator production without expanding the production areas and replacing equipment. Basing the plan on such indicators forces the plants to use various pretexts to avoid organizing the production of new and progressive designs that are light in weight and this impedes the expansion of the production output.

It is advisable for GlavPEU to place this question before the state planning organizations. Its positive solution will contribute to the development of fitting and insulator production.

The trust met with certain difficulties in developing the technical and economic substantiation for the modernization and re-equipping of its plants. The long-time lack of facilities for the planned and proportional development of all the services (including the auxiliary ones), as well as the impossibility of replacing obsolete equipment, has led to a situation where the plants are now forced to provide significant amounts of work in order to eliminate deficiencies and bring production up to the proper level. The realization of this work requires additional capital investments, which reduces considerably the technical and economic indicators of the modernization work being done. Simultaneously with the modernization of existing enterprises, it is necessary to implement measures for the development of auxiliary production facilities and services, replace obsolete and worn-out equipment, and perform operations for the protection of the environment. In view of this, USSR Minenergo's Division of Expert Opinions on Plans and Estimates should consider the necessity of increasing the capital expenditures in comparison with the existing norms and analogs and recommend for confirmation the plans for modernizing fitting and insulator plants that have been developed. This will make it possible, within the projected periods of time, to carry out the modernization, increase the capacity for fitting and insulator production, and provide the national economy with insulators and fittings in the required volumes.

In the trust a great deal of attention is being given to mastering and introducing progressive insulator and fitting designs. In particular, the SKTB [Special Design and Technological Office] has created a series of special suspension insulators with a guaranteed strength of 300 and 400 kN for ultrahigh-voltage (1,150 kV of alternating and direct current) power transmission lines and developed a complex high-voltage fitting for a split phase utilizing eight wires. At the present time, projects are being completed that have to do with investigating the characteristics of insulator chains, developing production processes for the plant manufacturing of insulators and fittings, and preparing production facilities so that their series output can be organized. The uniqueness of the designs that have been developed, the absence of analogs in the practice of worldwide fitting and insulator production, and the extraordinarily high requirements for the level of operational reliability required a qualitatively new approach on the part of the trust's specialists. Two automatic lines that include complicated production equipment, an automatic regulation and control system, and numerous transporting devices have been assembled and mastered in order to produce the insulators. The normative and technical documentation, in which the testing and acceptance requirements for the finished products were made more stringent, has been worked out and agreed upon with Energoset'proyekt [All-Union State Planning, Surveying and Scientific Research Institute of Power Systems and Electric Power Networks] and NIIPT [Scientific Research Institute of Direct Current]. The high-voltage fittings for these power transmission lines will be manufactured in a special shop at the Slavyansk fitting and insulator plant that is now under construction. Until the completion of this shop, its production assignment will be given to existing enterprises for which it has been proposed that special production lines be organized.

It should be mentioned that it is extraordinarily difficult to create all the necessary conditions for the implementation of this critical order in the existing shops. This fact again confirms the need for modernization of the fitting production process and the introduction of the new fitting shop as soon as possible.

Among the other new developments, we should mention the insulator designs with a cylindrically shaped power assembly that are intended for all classes of voltage, insulators made of polymer materials, and elements and designs for the rigid leads of the outdoor distribution systems of 110-500 kV substations.

Improving the traditional processes of fitting and insulator production is not the only work the trust is doing.

In conjunction with a number of scientific research institutes and planning organizations, it is creating the technology for the mass production of a fundamentally new product: ceramic RVP [possibly pneumatic timing relay] tubes. After the development of the technology has been completed, it is proposed that a shop with an annual production capacity of 10 million tubes be built.

The trust's SKTB is investigating special ceramic materials for the purpose of using them to manufacture insulators intended for atomic electric power stations and magnetohydrodynamic generators; work has begun on investigating the insulation of cryogenic installations.

Work on the industrial development of aluminum-plating of line fittings instead of hot zinc-plating is being completed. The technology that has been developed can be used for the aluminum-plating of the metal supports of power transmission lines at USSR Minenergo's metal designs plants.

An effective increase in the capacity of fitting and insulator production depends largely on the quality of the production output, with special emphasis on insulators. Therefore, work is constantly being done in the trust to improve the quality and reliability of the production output. Since 1976 the trust's plants have been manufacturing products of only the first and highest class of quality. In the current year, the production output in the highest quality category will be about 40 percent of the entire volume of fittings and insulators. The trust's production output operations for 1978, as attested to by the State Mark of Quality, were noted by a special diploma from USSR Gosstandart [State Committee for Standards] and the AUCCTU.

Specialization in the production of insulators and fittings and the organization of efficient intratrust cooperation enabled the fitting and insulator plants to achieve a continuous increase in the productivity of labor in addition to introducing measures for the mechanization and automation of production processes. For instance, from 1976 to 1978 about 90 percent of the increase in production output was the result of increased labor productivity.

The Elektroset'izolyatsiya trust, which contains industrial enterprises, a design and technological office with experimental production facilities, and construction, installation and assembly and transportation organizations, is solving the problem of providing the national economy with insulators and fittings on an integrated basis. This control has created favorable conditions for improving work efficiency and has enabled the trust to supply electrical network projects that are under construction with fitting and insulator products on a timely and operational basis.

However, in order to fulfill the present requirements for improving the system for controlling the industry, it would be advisable to create an All-Union specialized industrial association on the basis of USSR Minenergo's fitting and insulator industry. This will make it possible to accelerate the rates of scientific and technical progress and increase the effectiveness of the work of the plants and organizations in the association.

Preliminary calculations show that in connection with the creation of such an association, as the result of further specialization and expanded cooperation alone, as well as the improvement in the enterprise control structure, a significant economic effect can be obtained.

In conclusion we should mention that the persistent and selfless labor of the multithousand collective of the Elektroset'izolyatsiya trust's plants and organizations has received a high evaluation. For its development and mastery of new insulator and fitting designs and its timely supplying of them for the construction of the international 750-kV electric power transmission line from Vinnitsa (USSR) to Al'bertirsha (Hungarian People's Republic), the trust was awarded the Order of the Red Banner of Labor.

Inspired by this high government award, the trust's collective will solve the problems facing it with even greater urgency, strive for the fastest possible completion of the construction and modernization of its plants, enlarge the required production capacities, improve the structure of its production output, and improve the economic indicators of its own work and, thereby, the efficiency of all power construction.

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